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SCHOOL SCIENCE AND MATHEMATICS

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MATHEMATICS IN GENERAL EDUCATION*

JOHN C. BRYAN
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Many recent articles have mentioned the amount of mathematics and science that is being taught in the Russian schools. The implication appears to be that the American schools are not teaching these subjects as they should be taught or that the American schools are not offering the necessary subjects for the proper preparation of the future scientists and mathematicians.

The President of the United States is asking the people to study and improve the curriculum of the schools. Such a study should be of great assistance to the National Council of Teachers of Mathematics, the Mathematics Association of America, and the Commission on Mathematics of the College Entrance Examination Board in their efforts to improve the mathematics programs of the elementary and secondary schools. Besides studying the curriculum of the schools, studies and recommendations are being made which will affect the courses of study for college students preparing to teach mathematics and for teachers studying for advanced degrees.

The changes that can be made in the schools to improve the curriculum must be made by the teachers. The PTA and the school board, although they are sincerely interested in the improvement of the schools, cannot prepare the materials nor formulate the scope and sequence of the mathematics program. If you are interested in making improvements in your curriculum, there is no time like the present. You should have little difficulty in obtaining support for your program.

* A paper presented at the Annual Convention of the Central Association of Science and Mathematics Teachers, Chicago, Illinois, November 29–30, 1957.

The editorials of many papers, the letters from the readers, and even the writings and speeches of prominent persons are suggesting that we inaugurate programs similar to the Russian. But, the philosophy of America and of the public schools prevents us from requiring all students to study the same prescribed courses. There must be some freedom of choice for the students who do not wish to specialize in mathematics or science. We must find ways to encourage more students to continue their study of mathematics. Mathematics can be interesting to the students, a challenge to them, and a proper training for further study.

The American school was designed to teach all the children of all the people, regardless of their physical, social, financial, or mental endowments. The differences in the mental abilities of the students in the schools has affected, or should affect, the curriculum of the schools. During the past twenty-five years or so, the character of the school population has changed considerably. It was not too long ago that the elementary school was terminal education for many students and the secondary school was mainly college preparatory. Today, nearly all students begin high school. Of course, not all of these students complete the required program of studies, but a larger percentage of the students are completing their studies and graduating from high school than ever before. We cannot teach all of these students in the same way. Some will require the mathematics that is needed for personal and business use only, while others will need the prerequisite courses for advanced study. Most students will complete grades seven through ten, so the program here must prepare the student for work or for continued study.

These are still years of indecision. It is too early for specialization. It is too early to tell the student, "You are not qualified to go to college, you must prepare for a trade," or "You are to study only the theory of mathematics because you are going to college." Courses at this level should provide the mathematics that is needed by all people in their daily lives as well as the preparation for further study. A program based on this idea can be interesting to all the students, challenging to the better students as well as the poorer, and still provide an adequate preparation for future study.

A single course, offered at different levels, can provide the mathematics needed by the average citizen and it can provide the preparation for further study. At any given grade level, there is considerable difference in the reading ability of the poorest and best student, but the difference in their interests are not so far apart. The language of the text for the poorer student must be more simple than for the good student, but the material included does not have to be "watered down." The present sequence of arithmetic, beginning algebra and

plane geometry, offered in most schools, does not accomplish this task. New courses, similar to the Functional Mathematics series by Gager and others, are needed to meet the demands of more mathematics for more people.

A good military man, after a battle, reviews what has been accomplished and re-inforces his position, scouts ahead in preparation for the next battle, and studies the history of previous battles for possible applications to his particular position. The mathematics teacher could, in some respects, emulate the military man.

A course designed for general education should include a review, at intervals, of all the fundamentals that have been studied; a continued study of the concepts of arithmetic, beginning algebra and plane geometry; introductions to topics from intermediate algebra, solid geometry and trigonometry; and a study of the historical and cultural background of mathematics. Permit me to illustrate some of the problems in each of these areas.

The major part of the study of the skills and processes of arithmetic is completed in the seventh grade. Many students are able to begin the study of topics from beginning algebra and plane geometry. However, they will need reviews of the skills to better insure their understanding. But these reviews do not need to be a series of problems in addition, subtraction, multiplication, and division. New topics can be used which require these basic skills.

The computation of the yield of stocks and bonds, which are listed in the stock market reports, will give the students the needed practice in the use of decimals, fractions and percentage, and still be new and challenging to the students. Additional work of this nature can be found in the study of insurance or the Federal income tax.

When working with the special products of algebra, applications should be made to products in arithmetic. The product $(a+b)^2$ can be used to find the square of the nembers between 10 and 100. For example: $23^2=(20+3)^2$. Expanding this by the rule for the square of a binomial, yields $400+120+9$ or 529. The cubes of some numbers can be determined in a similar manner. The product 23×17 can be found mentally by considering it as the special product $(20+3)\ (20-3)$. These applications of algebra to arithmetic show the student that algebra is generalized arithmetic and provide him with some shortcuts that will speed up his arithmetic calculations.

These problems will also help the student to understand the meaning of place-value of the digits in a number, and the true meaning of carrying and borrowing in the problems of addition and subtraction of arithmetic numbers.

In the work involving geometric concepts, the proofs by algebraic methods should not be neglected. Often, they are easier to understand

and will provide a review of the concepts of algebra. The Pythagorean theorem is much easier when proved by using algebra than when proved by using the geometry of areas.

One of the difficulties encountered by students who follow the customary succession of courses; beginning algebra, plane geometry, and intermediate algebra, is that there is insufficient review of the concepts of algebra during the plane geometry course.

Because the eighth grade is no longer terminal education, there is no longer a need for a review of the concepts of arithmetic at this point. Instead, the students could be introduced to the concepts of algebra and geometry. Some of this is already being included in eighth grade textbooks, but more can be done to accelerate the good students. The work with formulas provides an introduction to equations and the making of geometric designs will teach the use of the straight-edge, compass, and protractor. These students are then ready to learn more about equations and the geometric constructions. They should be introduced to the proper terminology of equations: members, terms, coefficient, equality, root, etc.; and of constructions: arc, point, perpendicular, bisector, angle, inscribed, circumscribed, etc.

The student, when introduced to these concepts formally, will have little fear of them because he already has a nodding acquaintance with them. The student will find in the new topics something familiar and he will accept the new topics more graciously. The teacher, in turn, can use the previous work as a stepping-stone to the new and more complex problems.

The student, who has studied the areas of rectangular figures, can use them to illustrate the special products $(a+b)^2$, $(a+b)$ $(a-b)$, and many others.

Throughout the mathematics program, new topics should be introduced in advance of the complete discussion of the concepts. But this is getting into the next section on the introduction of advanced topics.

When the concepts of algebra and geometry are introduced earlier in the student's career, there is additional time available for the study of advanced topics. These topics are extensions of the concepts that are normally studied in the program.

The binomial theorem is only a step away from the special products. Of course, ninth graders would find the general form of the binomial expansion too difficult, but the triangle of Pascal is easily constructed by means of an algorithm and the students can use this to expand binomials up to about the tenth power. Students can be shown how these expansions can be used to compute the powers of arithmetic numbers.

Certain theorems and properties of plane geometry suggest exten-

sion into three-demensional geometry. As an example: Two lines in a plane are parallel or they intersect; but two lines in a three-dimensional space are parallel, or they intersect, or they are skew lines. If the lines were replaced by planes, then two planes are parallel or they intersect. It is not necessary and probably not desirable to prove these statements about the three-dimensional space, but the students would be acquainted with it and should feel more at home with the concepts of solid geometry.

Along with three-dimensional geometry, some of the concepts of projective geometry could be introduced. Statements, such as: Two points determine a line and two lines determine a point; could be used as illustrations of the concepts of the infinity of the line and the duality of point and line.

The study of geometry can be made more "modern" by including the study of the surface of the sphere. At the speed of the modern aircraft and missile, the shortest distance between two points is not the straight line of Euclid but the great circle arc of Riemann. In this modern age of world travel, students need some knowledge of spherical geometry if only to understand geography and why shipping routes are as they are.

In the eighth grade, problems in percentage lead to the discussion of ratio, proportion, and similar triangles. Why not go one step further and study the problems of numerical trigonometry? All that is needed are the principles of similar right triangles, a table of trigonometric ratios, and arithmetic. With this background, it may be possible to include the solution of simple trigonometric equations along with the solution of algebraic equations.

Toward the end of the tenth grade, a section on the use of logarithms and the slide rule would be helpful for students planning to take physics or chemistry the following year. Certainly, a complete study of a complex slide rule should not be undertaken, but the scales of a beginner's slide rule could be studied. The study of the slide rule and logarithms would also provide a review of the principles of exponents.

Students, I fear, somewhere get the impression that the study of mathematics is restricted to the problems that are found in the textbooks. There are many good books on the history of mathematics and its effect on our culture that would add measurably to the program in mathematics. Few courses in our schools are bound to one textbook as are the courses in mathematics. Students should have the opportunity, and should be encouraged, to explore the field of mathematics without regard to its immediate application to the course.

America is able to supply large numbers of technicians in all fields when demanded, but is unable to produce the Einsteins, the Stein-

metzes, and the Gausses that are needed to do the thinking and dreaming that is such a large part of basic research.

These people were deep thinkers because they had a broad knowledge and a desire to learn more. I would rather teach a class which is always asking questions than a class which is satisfied with learning what is in the textbook and does not think beyond the present problems. The teacher can, by small degrees, encourage the class to think. Offer them a problem which cannot be solved by the methods that they are studying. Show them some elementary problems from symbolic logic, number theory, or modern algebra.

As examples of some of the reading materials, I might suggest Hogben's "*The Wonderful World of Mathematics*," Ogilvy's "*Through the Mathescope*," and Newman's four volume work "*The World of Mathematics*." I would recommend only the historical sections of Newman's books for the ninth and tenth grades. These are only three of the many excellent books that are readable by high school students.

The publications of the National Council of Teachers of Mathematics, including their Student Journal, and the publications of the Central Association of Science and Mathematics Teachers have many articles that are readable by students in this age group. Even if they read something that is above them, they may gain something from it. However, I warn you, be prepared to answer some difficult questions. You are supposed to know all of the answers.

There are many free and inexpensive publications by various corporations which contain information of interest to students. These are generally well written and easy to read. The *Scientific American* contains a monthly feature on mathematics which is written in the popular vein but very worthwhile. Most schools probably subscribe to this publication.

The reorganization of the mathematics program should begin in the seventh grade. Only by beginning there can unnecessary duplications be eliminated, and certain concepts introduced, making room for the newer and more modern concepts demanded by the present atomic age.

The program should use the integrated approach. Arithmetic, algebra and geometry are not separate subjects; each helps to explain the other. Most textbooks use topics from the other areas as resources for problems or as illustrations of the principles being discussed.

Even though unnecessary repetitions are eliminated, a four year period is needed to complete the study of the topics. But the students would have a better understanding of the principles of mathematics and it may encourage more students to study mathematics longer than the minimum required for graduation or college entrance.

During 1955 to 1957, we experimented with a two-year integrated

program for the ninth and tenth grades. We found that many students achieved beyond what would normally be considered their maximum. Students who were one or more grades below their group in arithmetic achievement were able to succeed in the abstract thinking of formal geometry.

The better students had a good understanding of the advanced topics, which were taught as optional sections, and have shown that their background preparation is sufficient to permit them to compete with equivalent students from the traditional courses when studying intermediate algebra.

Although this is not decisive evidence, it indicates that programs of this nature can provide the necessary background for further study as well as strengthening their understanding of the processes of arithmetic. With improvements in the textbooks and additional experience on the part of the teachers, the course could provide a better background for the students.

More experimentation to determine the exact scope and sequence of a program of this type is needed. Few comparative studies have been made of the importance or unimportance of the order of the topics of these programs. One major complaint of the integrated program is the lack of continuity. This will be overcome as revisions are made which are based on the suggestions of the teachers who have taught these courses. Then, the students will find a smooth, continuous program which is interesting and filled with good mathematics.

CANDIDATES FOR 1958 ELECTION

Every member of the Central Association of Science and Mathematics Teachers, please take notice. To conform with action taken at the November, 1957, Association business meeting: "Publication of the personnel of this (Nominating) committee shall be in an early issue of SCHOOL SCIENCE AND MATHEMATICS. At this time the membership shall be invited to make suggestions of prospective candidates to any member of the Nominating Committee."

Suggestions are solicited now as follows (two names for each of the following offices):

> "President, Vice President, and at least four Board members and a brief statement on the qualifications of each nominee . . . " for consideration by the committee.

The committee is obliged to set April 1, 1958, as the deadline for such suggestions to enable the committee to prepare and submit the list of nominees to the 1958 Spring meeting of the Board of Directors as required.

The addresses of the members of the Nominating Committee are:

Muriel Beuschlein, Chicago Teachers College, Chicago, Illinois
Edward Bos, Proviso Township High School, Maywood, Illinois
Robert E. Carpenter, 3216 Berwyn Lane, Richmond, Indiana
Glenadine Gibb, Iowa State College, Cedar Falls, Iowa
Allen F. Meyer, Chairman, 255 South Denwood Drive, Dearborn 7, Michigan

A STATE LEVEL APPROACH TOWARD IMPROVING SCIENCE EDUCATION

Bruce K. Nelson
Eastern Michigan College, Ypsilanti, Michigan

Back in the days when the earth had only one moon, some people were more concerned than others about why so few of our talented youth show an interest in science. In Michigan, expression of this concern by a group of science educators resulted in a state level approach to the problem which, both because of its accomplishments and shortcomings, may be of interest and assistance to persons in other states as Americans everywhere, suddenly aware of the rapid and significant scientific progress in Russia, begin critically to examine science education in their schools.

It was in December, 1955, that several science teachers from universities, colleges, and secondary schools met with the Curriculum Planning Committee of the Michigan Department of Public Instruction and urged the establishment of a state level committee on science education. Those unfamiliar with the Michigan pattern of curriculum development should know that for many years it has been the policy of the Department of Public Instruction to provide educational leadership through the sponsorship of approximately twenty curriculum advisory committees. This policy has been singularly rewarding in stimulating marked instructional improvement at the local school level through the participation of representatives on the various committees, voluntary cooperation in research, and action on committee projects by many school districts. Operation according to this pattern has entailed a minimum of state central control and supervision.

In recommending to the Superintendent of Public Instruction that he appoint a science committee, the Curriculum Planning Committee stated its conception of the group's role as involving: (1) Gathering and describing in some detail the projects going on in science education, and (2) beginning work at once on improving science instruction at elementary, secondary, and higher education levels, developing programs for the gifted, providing specialist help for the unspecialized teacher, studying curricular requirements in science for certification of elementary and science teachers, surveying attitudes toward science held by the people of Michigan, and many other problems of a similar nature.

To determine whether or not the functions of such a study group were already being fulfilled by one or more of the score of other state-level curriculum committees and also to explore more fully the possible contributions a committee would make, Superintendent of

Public Instruction Clair Taylor, in January 1956, appointed an *Ad Hoc* Committee on Science and Technical Education. The composition of this preliminary group was to set the pattern for the committee which followed. It included elementary, secondary, community college, four-year college, and university teachers in science, mathematics, technical and vocational subjects. Others were administrators from all school levels. Still others were representatives of industry—one from automotive manufacturing, one engineering consultant, and one from a photographic equipment company. Two members of the Department of Public Instruction staff also participated.

In May of 1956, the *Ad Hoc* Committee recommended that a committee on Science and Technical Education become an integral part of the state curriculum committee structure. Superintendent Taylor, during the summer of 1956, chose appointees from the fields of education, industry, and labor and in September of that year the new committee began its deliberations at a two-day conference attended by all of the state curriculum committees.

It was at this conference that members of the science group first sensed the apprehension felt by their colleagues in other disciplines that this new committee had been organized for the purpose of enticing all of the most talented young people into careers in science. Recognizing that such a misunderstanding would seriously jeopardize the committee's program, the committee prepared a statement of philosophy, designed to clarify its position and allay fears. The statement, which follows, was publicized throughout the state in newspapers, magazines, and releases of the Department of Public Instruction.

PHILOSOPHY OF SCIENCE EDUCATION CURRICULUM COMMITTEE

Although there is ample evidence to indicate that there is today a dearth of persons adequately prepared in science and mathematics to meet the demands of teaching, industry, and research, the state committee on science education in Michigan considers its chief concern to be the design of well-balanced educational programs which will meet the *long range* needs of individuals and of society.

We conceive of two types of needs: (1) the general educational needs of all students, (2) the more extensive and additional needs of those who may become specialists.

An understanding and appreciation of the forces at work in our modern culture has become so dependent upon a citizen's having some insight into the fundamental concepts of science and mathematics that today, more than ever before, every student must have adequate experience in these areas as a part of his general education.

The students who are potentially specialists in science and technology have a further need—enough experience of a sound and rigorous nature that they may judge whether or not their own interests lie in this direction. Further, for the sake of those who do decide to specialize in this area, it is important that their instructional programs have been such that they may proceed to further study without loss of time and effort.

The committee is confident that, with an allotment of time and effort in grades kindergarten through fourteen comparable with that given to other major areas of the curriculum, programs can be designed which will meet these educational needs, and will, in the long run, supply increased numbers of scientists, mathematicians, and technicians for teaching, industry, and research. The committee further believes that these increased numbers can be obtained without siphoning away from equally important non-science areas a disproportionate number of those persons with superior abilities and broad training who are so necessary in all areas such as public service, religion, and the professions.

Reaction to the statement appears to have been generally favorable. It states clearly the committee's concern for a well-balanced educational program, and at the same time leaves no doubt that such a program should contain for science "an allotment of time and effort . . . comparable with that given to other major areas of the curriculum."

Having agreed upon a philosophy, the committee proceeded to identify the specific instructional problems which might be attacked. Many were listed. It was found helpful to categorize them in three major groups:

Curriculum centered problems—e.g., examination and evaluation of science education in the elementary school.

Teacher centered problems—e.g., development of in-service programs and services, such as workshops, consultant help, and conferences to assist teachers to become better instructors in science.

Student centered problems—e.g., encouraging the identification of science talented and interested youth who should be stimulated through scholarships, summer work in scientific situations, and other means to enter the fields of science teaching, science, engineering and technology.

The problems classified in each category were so numerous it soon became apparent that the group would be effective only if it concentrated its efforts in one area. Consequently, it was agreed that the initial study should be in the area of curriculum centered problems. Three sub-committees were formed; one to examine problems in elementary school science (grades Kindergarten through six), another to study science in general education (grades seven through fourteen), and a third to be concerned with specialized education in science (grades eleven through fourteen).

For several months the sub-committees worked assiduously at their tasks. The science in general education sub-group evaluated and then endorsed the Michigan Science Teachers Association proposal which calls for this science curriculum structure in secondary schools:

Grades 7 and 8—For all students—General Science
Grade 9—For all students—General Biology
Grade 10—For all students—General Physical Science
Grades 11 and 12—For specializing students—Advanced Physical Science, Advanced Biology, Physics, Chemistry, Vocational Sciences (radio, electronics, etc.)

The other sub-committees discovered that curriculum-centered problems at their school levels were closely intertwined with the preparation of qualified teachers. The elementary sub-group recommended to the National Science Foundation that a summer institute program be developed for elementary teachers, wrote to leaders in six professional organizations in the state requesting that they bring to the attention of their members the need for improvement and expansion of elementary science curricula, and was instrumental in activating elementary science section meetings at the fall regional conferences sponsored by the Michigan Education Association. The sub-committee for specialized education explored the possibility of up-grading secondary school science and mathematics instructors by having industry employ them during the summer months in research activities compatible with their areas of teaching.

Again and again as the sub-committees discussed their various projects they were confronted with questions as to whether their proposals were in line with the overall objectives of the parent committee. Thus it soon became evident that the latter group must expand its statement of philosophy by agreeing upon some broad objectives. From committee deliberation came the following:

BROAD OBJECTIVES FOR SCIENCE EDUCATION FOR KINDERGARTEN THROUGH 14th GRADE

I. All science experiences should be designed as a quest or search in which the student should:
   A. Grow in his understanding of the basic ideas and information in significant areas of science and his consideration of the interrelationships in science and non-science areas.
   B. Learn to:
      1. Observe his environment and report accurately what he has observed.
      2. Develop and use functional skills.
      3. Make comparisons of likenesses and differences.
      4. Evaluate the importance of information.
      5. Determine the kinds of information he still needs to realize the goal.
      6. Identify and use the most efficient way to gain the information.
      7. Apply the information obtained.
   C. Recognize the contributions and social implications of science to daily living and use them in his thinking and in his actions.

II. In science instruction the teacher should attempt to do the following:
   A. Provide a well balanced distribution of experiences in the significant areas of science.
   B. Stimulate the student's curiosity about this environment and encourage him to become interested in and concerned about the "why" of his environment.
   C. Provide opportunities for the student to identify himself with and enjoy elements of his biological and physical environment.

At this writing, one year after the formation of the original group, a revised Committee on Science Education (Technical education, as such, was assigned to another of the state committees) is struggling with the task of implementing those broad objectives. Plans are being

made to move forward vigorously using publications, conferences, institutes, workshops, and offering consultant help where requested.

On the basis of its experience during the past year, however, it is apparent to the committee that it will make its most effective contribution over the long range. Committee acceptance of a philosophy, the establishment of broad objectives and the identification of problems are apt to have little immediate impact on what happens in the classrooms in the state—and yet these are tasks which need doing. Their resolution provides the framework for action—whether the action be of short or long range.

If in the interests of national security a more intensive crash program for stimulating scientific education is needed, the committee, because of its lack of financial resources, the absence of full-time or even part-time staff, and its limitations as an advisory group, cannot conscientiously assume responsibility for such a program. Nevertheless, the committee has provided for the people of Michigan a sound basis for development of an action program, and it promises to make further contributions of merit in the long range struggle to establish and maintain effective education in science.

NEW ANTI-LEUKEMIA DRUGS DEVELOPED

Two new anti-leukemic drugs that promise to be more effective than amethopterin, a drug now in standard use, are about to undergo their first trial in human patients at the National Institutes of Health.

Animal studies have shown that both drugs give longer survival times and are less toxic than the older drug.

The new ones are chemically similar to amethopterin and are known technically as monochloroamethopterin and 3′,5′-dichloroamethopterin. All of them are folic acid antagonists.

NEW LAND CAMERA TAKES AND DEVELOPS SLIDES

Dr. Edwin H. Land, inventor of the now famous camera that bears his name, has invented a simple and inexpensive camera for taking and developing 35 millimeter (mm) transparencies.

In addition, the camera can be used without modification as a viewer for seeing the slides that were produced only seconds before. When a light source is provided, the combination camera-viewer can be converted into a projector for showing the slides on a screen.

Dr. Land describes his latest camera development as an inexpensive box type. He says it is capable of making a single exposure and processing it into a finished positive transparency. Dr. Land also points out that it is very simple to operate, requiring only the insertion of the film and its removal after exposure.

For viewing, Dr. Land has provided a ground glass or transparent plastic window in the camera's back. This is light-tight when pictures are being taken. A finished slide is slipped into position in front of the window and the viewer peers through the lens of the camera. When a strong light is put behind the window, the camera can be used as a projector.

ARGONNE NATIONAL LABORATORY—PAST, PRESENT, AND FUTURE*

STUART MCLAIN
Argonne National Laboratory, Lemont, Illinois

INTRODUCTION

It is the purpose of this paper to discuss the history of Argonne National Laboratory; its present organization, personnel, and facilities; and to indicate the future trends of its work. While the discussion is necessarily brief, emphasis is placed on the purpose for the Laboratory and the main programs which are being carried out at present.

HISTORY

Argonne National Laboratory was started during World War II as the Metallurgical Laboratory of the University of Chicago. During 1939 and 1940, the general concept of nuclear fission reactors was worked out in several university laboratories including Columbia University. The Columbia group started efforts to obtain materials for building an exponential or subcritical reactor in 1941. This work progressed rapidly in spite of the tremendous difficulties involved in obtaining high purity uranium and graphite.

With the decision to expand this work into a major project, the entire program for development of a nuclear reactor was transferred to the University of Chicago. This was done early in 1942. The development of heavy water was left at Columbia. Two of the people transferred from Columbia University were Enrico Fermi and Walter Zinn. This group, under the direction of Arthur Compton, proceeded to build larger exponentials. The work culminated in the first critical fission reactor on December 2, 1942, as Chicago Pile No. 1, or CP-1.

Early in 1943, the CP-1 reactor was moved to a more isolated site in the Argonne Forest about 25 miles southwest of Chicago near Palos Park. The reactor was set up on a permanent foundation and shielded. This reactor was used as a very important research and development tool until May 1954 when it was shut down and dismantled. Recently, a portion of the core has been reassembled as an exponential and is used by the students in the International School.

When the University of Chicago group was set up, it was designated as the Metallurgical Laboratory under the direction of the Office of Scientific Research and Development and later as a part of the Manhattan District, organized to develop nuclear bombs. The

* Talk presented at the Annual Convention of Central Association of Science and Mathematics Teachers, Gold Room, Congress Hotel, Chicago, Friday, November 29, 1957, at 9:10 A.M.

Laboratory was rapidly expanded to include work on design of nuclear reactors, fuels, and recovery of the plutonium produced in the reactors. The du Pont Company was brought in in 1943 to supervise the design and construction of the pilot plutonium separation plant at Oak Ridge and the production facilities at Hanford. This part of the story is well known.

Of interest here is that along with the research and engineering on reactors for production of plutonium, a large group of research and development people were collected to work on the related problems of health physics, biological effects of radiation, chemistry of the transuranium elements, metallurgy of uranium, and recovery of plutonium. The leaders of these people were the top scientists and engineers in the country. Facilities were built or rented, and extensive laboratories of a temporary nature were built.

With the completion of the first bombs and the end of the war, the organization and interests of the Laboratory rapidly changed. Many of the top scientists and engineers returned to their former positions in various universities and industrial organizations. However, some of the top people continued in the Laboratory, and most of the young scientists and engineers remained. It was obvious to these people that the development of the nuclear field, including nuclear power, would be a continuing challenge for many years, and the work would be very rewarding. It is these younger people at Argonne and the other nuclear laboratories such as Oak Ridge that should receive the major share of the credit for the development of the nuclear field.

After the end of the war, the engineers and scientists continued to work on the same research and development problems they had been working on as a part of the Manhattan District work. Some thinking about nuclear power had occurred during the war and a few conferences had been held to discuss what might be done. As a matter of fact, there was very little change in the program because the work was of a basic nature, and most of the specialized engineering work for Hanford had been completed.

With the organization of the Atomic Energy Commission in 1946, plans were made for establishing Clinton Engineering Works at Oak Ridge and the Metallurgical Laboratory on a permanent basis. These were renamed Oak Ridge and Argonne National Laboratories and given permanent status. Brookhaven National Laboratory was organized, and the Laboratories at Hanford and Los Alamos were given a permanent status. The University of Chicago continued to operate Argonne for the Government under contract with the Atomic Energy Commission.

It was apparent that Argonne should be physically separated from the University and given permanent quarters. This was necessary be-

cause of the physical size of the Laboratory buildings and the requirements of considerable isolation for some of the work. A new site was purchased near the Palos Park site. This site is just north of the Des Plaines River north of Lemont and covers an area about three miles square. Much of the land was forested at the time it was purchased for the Laboratory.

Construction of facilities was started in 1947. Due to the desire to get buildings up quickly, several so-called temporary quonset type buildings were constructed. These are now considered permanent. Permanent buildings were constructed for all laboratories containing radioactive materials except Metallurgy which was housed in quonset buildings. This construction program cost about $65,000,000, with $21,000,000 additional for equipment. As buildings were completed, the various divisions were moved from their old quarters at or near the University of Chicago. The last division to move to the permanent site was the Biological and Medical Research Division which moved in 1954.

Organization

The organization of the Laboratory has been surprisingly stable since its beginning on July 1, 1946, under the Atomic Energy Commission. The Laboratory is officially a part of the Atomic Energy Commission in that its facilities are owned by the United States Government through the Commission; all operating and construction funds are supplied by the Government; and the research and development programs are approved by the Commission.

The Atomic Energy Commission is a semi-autonomous part of the Executive Branch of the Government. The Joint Committee on Atomic Energy of the Congress follows the legislative needs of the nuclear field. The basic laws were the Atomic Energy Acts of 1946 and 1954. The Joint Committee also reviews the yearly budget and programs of the Commission, and all members of the Committee are given the detailed technical information which is classified.

In addition to review by Congress, the Atomic Energy Commission's program is under continuous scrutiny by the Bureau of the Budget. The Bureau has been very cooperative, even though the requirements for funds have been growing rapidly in the face of attempts to hold a level national budget.

The Atomic Energy Commission in Washington is organized into a General Manager's Office and various divisions. In general, the research and development divisions correspond to the same divisions in the various research laboratories, as indicated in Figure 1. The Commission has organized Operations Offices, and all matters must flow through these offices, particularly contract and budget items.

Technical information, in theory, flows across all lines of authority.

Research and development work is controlled by the various divisions of the Atomic Energy Commission. These include: Research, Biology and Medicine, Raw Materials, Production, Reactor Development, and many others. Most of the work carried on at Argonne comes under the Biology and Medicine, Research, and Reactor Development Divisions. The control operations, including budgets and contracts, for the University of Chicago's contract to operate Argonne National Laboratory is administered by the Chicago Operations Office, located on the actual site at Argonne. In addition to Argonne, the Chicago office contracts with many universities and industrial companies for research and development work.

The University of Chicago has in turn set up definite policies for its operation and concerns itself primarily with the legal and budget problems of the Laboratory. The legal procedure of contracting for operation of its facilities permits the Commission to have most of its people under non-Civil Service rules and policies. Thus, the policies on employment, salary, vacations, retirement, etc., at Argonne are those of the University of Chicago and not of Civil Service. This is very important and has led to a definite academic atmosphere at Argonne, particularly in the research divisions.

In order to foster relations with the midwest universities and to create a broad atmosphere for research and development, a Participating Institutions Committee was set up with 32 universities. At least yearly meetings of the representatives of the Universities have been held at the Laboratory. Recently, this organization has been changed and an Advisory Committee to the President of the University of Chicago has been organized. It is not yet clear how the new organization will function.

Within Argonne, the organization is broken into two general groups —the research and development divisions and the service divisions. The organization consists of a Laboratory Director's Office with a Laboratory Director; a Business Manager; Associate Directors for Research, Development, and Education; two Assistant Directors; and immediate staff.

The research divisions include Applied Mathematics, Biological and Medical Research, Chemistry, Particle Accelerator, Physics, and Radiological Physics. The development divisions include Chemical Engineering, Electronics, Metallurgy, Reactor Engineering, and Remote Control. There is, of course, considerable research work done in the development divisions and also considerable development work carried out in the research divisions.

In addition to the divisions listed, there are several scientifie divisions: Idaho, International School, Technical Information, and Re-

actor Operations. All other functions of the Laboratory are handled by the Technical Service and Business Administration Divisions. The Technical Information Division has the responsibility for care of all documents, including classification questions. The Division also reviews all reports issued by the Laboratory.

At present Argonne has slightly over 3,000 employees, including about 800 scientific people. The 1958 Budget includes about $32,000,000 for operations, $2,500,000 for equipment, plus the construction funds discussed below.

RESEARCH AND DEVELOPMENT

On what basis can we justify the existence of such laboratories as Argonne? Why do the American people finance and support over 3,000 people in research and development work? What are the products that these people produce? Of what value are these products to us?

To answer these questions we must try to define what is meant by research and development. There is no clear distinction between these terms, and research is frequently differentiated into pure research and programmatical research. Let us define research as that field of human endeavor in which new facts about nature are found through laboratory investigations, mathematical analysis, or other means. If the work is the investigation of fundamental properties of matter, we would call it pure research. If the work is measurement of special properties of these materials needed to design a power reactor, we would call it programmatical research. Obviously, there is no clear distinction between these terms. The true scientist or pure research person is not concerned with the application of knowledge. His service is to increase the sum total of human knowledge and not be concerned with the use of this knowledge. For example, in Fermi's attempt to produce a transuranium element, which led to nuclear fission, he was not concerned either with bombs or power. These are developments which have been based on his pure research.

Development may be defined as that field of human endeavor in which basic facts obtained in research are extended to and integrated with known production processes. Development is primarily an engineering function while research is a scientific and mathematical function. Of course, again, there is no clear distinction between terms. The development engineer is basically concerned with the application of knowledge to the production of goods for the good of mankind.

The existence of large research and development laboratories such as Argonne is a relatively recent historical development. Their products are ideas and numbers as presented for public use in formal reports, papers, and lectures by the scientists and engineers.

The idea for such laboratories was derived from the military test or proving grounds and such laboratories as the Bureau of Standards Laboratory. The step from routine testing of a military weapon, a thermometer, or a scientific instrument, to suggestions for improvements or development is short and obvious.

The National Advisory Committee for Aeronautics Laboratories were the first laboratories set up to carry out research and development in a specific field. The National Laboratories in Atomic Energy are similar to the NACA Laboratories, except they carry out research and development work in the nuclear field.

Research and development work at Argonne is carried out in all phases of the nuclear field except weapons. The work at Argonne has been closely related to weapons materials production, since the same materials are used in weapons and power production.

Research

Nearly all the research work carried out at Argonne is related to the nuclear field. In general, the research work deals with the production or the utilization of the various nuclear radiations. Some of the research work is related to the programs carried out in the development of nuclear power reactors.

Approximately one half of the scientific staff of the Laboratory is assigned to research work. The general facilities of the Laboratory, such as the machine shops, computers, and research reactor, are available to all research and development people. Many of the scientists and engineers have technical assistants assigned to them on a full time basis.

A few of the general programs to which Argonne has made contributions are mentioned in the following paragraphs. These should be considered as examples rather than a resume of the work.

The work in physics has been concerned with the properties of the basic particles, neutron physics, instrumentation, reactors, and related subjects. The work on basic particles has been concerned primarily, as would be expected, with the reactions of neutrons with various materials. Work has been carried on continuously at Argonne in measurement of the so-called cross sections of materials for neutrons of various energies as this work is of great importance in design of nuclear reactors of all types. Various reactor designs and methods of computation have been carried out along with the interpretation of the basic neutron measurements. The measurement of neutron energies is a very complex and difficult problem since the neutrons have no charges and can only be identified by their reactions. The determination of the energies and numbers of neutrons in reactors has been particularly difficult, and no satisfactory method for meas-

urement has been developed to date. Considerable mathematical analysis has led to a better understanding of the reactions that take place in reactors. Of particular interest has been the analysis of the behavior of fast reactors.

The work in instrumentation has led to the design of highly specialized instruments for use with nuclear reactors and radioactive isotopes. Among these has been considerable development of the scintillation counter.

Work on basic particles has led Argonne to construct a 60 inch Cyclotron and a 4 Mev Van de Graaff Accelerator. Both of these instruments have proven to be excellent work tools. At present, a 12.5 Bev Proton Accelerator is being designed for early construction for investigation of the properties of the basic particles. The design of this instrument has been based on the premise that a high particle density is important, and no attempt has been made to create the highest possible energy machine. However, this project is a major one, as the present estimated cost of the machine is $27,000,000.

Argonne is doing very interesting work in the identification and measurement of the gamma rays emitted during various nuclear reactions. While not spectacular, this type of work is of great importance. For example, this particular work is basic to the design of shields for power reactors.

The development of the neutron diffraction spectrometer has enabled us to obtain an understanding of the structure of many alloys, including the hydrides. The future application of the neutron spectrometer promises to be as important as the use of x-rays in crystal structure work.

The work in biology and medicine has been primarily concerned with the determination of the effects of various radiations on the human body. This has led directly to the investigation of the basic life processes, and work on the basic reactions in living cells is under way. The manufacture and use of organic compounds using carbon-14 and tritium is aiding in this work. It should be pointed out that Argonne does not make any large amounts of radioactive isotopes.

Argonne people have always been interested in the transuranium elements. The separation of plutonium was first carried out in the Metallurgical Laboratory, and Argonne has continued to work on the heavy elements. The manufacture and identification of Nobelium in cooperation with British and Swedish scientists is the latest important discovery. More important has been work on the development of the methods for separation and identification of the heavy elements.

Extensive work has been carried out on helium-3 at temperatures of a fraction of a degree absolute. Any theoretical treatment of the structure of matter must account for the strange properties of this

isotope. The isotope is produced as a by-product of the manufacture of tritium.

One of the most interesting programs now under way involves design and construction of mass spectographs of greatly increased accuracy. Argonne has become interested in the development and use of computers, and two large computers have been designed and built.

Considerable basic research in chemistry, metallurgy, and physics has been designed to assist the development of nuclear reactors. Some of this work is mentioned under the various reactor programs below.

Development

The development work has been involved with the design and construction of nuclear reactors. While about the same number of scientists and engineers are involved in development as in research, the costs of equipment and experimental work in development is usually several times that in research. This is true since small scale pilot plants must be built and operated, and relatively large reactors must then be built and operated. Argonne has been responsible for part of the work leading to the Hanford and Savannah River production reactors, the Materials Testing Reactor, the Submarine Reactor, and the Heavy Water Research Reactor, and most of the work on the original Graphite and Heavy Water Researeh Reactors.

Work in power reactors has involved work on Boiling Water and Fast Breeder Reactors. At present Argonne has in operation a small Fast Breeder Reactor, a small Experimental Boiling Water Reactor, and a pilot plant size Boiling Water Reactor producing 5000 kw of electrical energy. Three of the six U. S. reactors, other than the Submarine Reactors, to produce power to date were designed and operated by Argonne. A larger Breeder Reactor is under development. This reactor is expected to be built in the next two years and will produce 20,000 kw or a net 17,500 kw of electrical energy. In addition to the reactors themselves, Argonne carries out work on development of alloy or ceramic fuel elements; corrosion; heat transfer; low power reactor experiments; design and operation of the reactors; and separation and recovery of the irradiated fuel. Detailed design and construction is always contracted with architect-engineers and construction companies.

Beginning in 1950, with the work on the Savannah River reactors, the work on the various reactors has been set up as projects under project managers or coordinators. This was made necessary since the development of a reactor involves staff people from many of the divisions, and the work of these divisions must be coordinated by a single individual. The coordinator is set up in some cases as a part of

the Laboratory Director's Office and has responsibility for organizing and coordinating the work in the various divisions. For example, in the development of the Savannah River reactors, there were over 140 technical people from several divisions working on this program at one time.

Actually, it is about as difficult to design and construct a small development reactor as it is to design and supervise the construction of a large production reactor. In each case, almost the same items must be considered and the same problems solved. The basic nuclear physics of the reactor must be calculated and evaluated; the instrumentation must be developed; the fuel elements must be designed and developed; heat transfer and stresses calculated; and the entire reactor system designed and carried through detailed calculations and design. Usually, a full scale, very low power mockup of the reactor core is built and used in extensive tests of the fuel patterns, neutron flux patterns, control problems, and other basic investigations.

The production of low cost electrical power from nuclear fission reactiors involves development of low cost fuels, efficient nuclear reactor power plants, and inexpensive recovery of the irradiated fuels and storage of the fission products. The production of lowered fuel costs has been attacked in several ways. Lower production costs of uranium fuel is promised through application of the fluidized bed techniques which have contributed so much to improved gasolines. In this process, uranium ore is ground, the uranium oxides are reduced in high temperature fluidized bed chambers with hydrogen to the lowest oxide, UO_2, and hydrogen fluoride is run over the material to form uranium hexafluoride which is vaporized out of the bed and condensed. This material, after a simple redistillation, is pure enough for use in production of uranium-235 or for production of reactor fuel. This process is expected to result in a drastic reduction in uranium costs.

Much has been written about the short life of fuels in nuclear reactors. The fuels are damaged by the irradiation and about 0.2 to 0.4% of natural uranium can be used before the fuel must be removed from the reactor, dissolved in acid, purified in solutions, and precipitated and formed into metal or oxide fuel elements. New alloys and ceramics show promise of fuel life of five to ten times those possible with pure uranium.

Irradiated fuel is recovered by expensive solvent extraction processes as indicated above. Several laboratories have been experimenting with simple slagging processes. Such a process, which has been recently developed, will be used in the fast breeder. Designs are well along on a pilot plant. Costs are expected to be low in a full scale plant.

Work on corrosion, heat transfer, and the components that go into reactors show promise. For example, aluminum alloys recently developed appear to be practical in pure water at temperatures several hundred degrees higher than was possible a few years ago. In 1950 we considered that aluminum could be used to 200 F. as a maximum; now we believe that some of the newer alloys can be used at temperatures as high as 600 F. in pure water.

The development of nuclear power promises to provide ample energy for a long period. Fuels for fission type reactors are probably 100 times as plentiful as the fossil fuels of oil, gas, and coal, and the fuels for fusion reactors are inexhaustible. As of today, only fission type power reactors which use uranium and thorium are under development, although research work on fusion reactors is being carried forward in several laboratories.

Work at Argonne is directed toward the development of reactors that will produce power at competitive costs. Basic work on heat transfer and development of special equipment, such as liquid metal pumps, is carried out on a large scale.

Educational Program

The International School of Nuclear Science and Engineering was organized in 1955 as a part of the Atoms for Peace Program. About 40 engineers and scientists come to this country for a semester's work at one of the regular universities teaching nuclear science each semester. These plus about 20 Americans attend the International School at Argonne for the second semester. To date, five groups of students have completed the work. These have included 215 students from 41 foreign countries plus 79 students from the United States. Courses in the International School consist of Nuclear Physics, Metallurgy, Reactor Engineering, Chemical Engineering, Chemistry, and Instrumentation.

Argonne sponsors a broad program of training U. S. industry and university people. On-the-job training of industrial and government personnel has included about 300 people (123 of these were du Pont people sent to the Laboratory for training for work on the Savannah River reactors). The on-the-job trainees usually work at Argonne for two years in the laboratories doing research or development work in the specific fields in which they will work in their own plants.

Argonne also hires a number of university instructors and students in the Laboratory for the summer months. Some M.S. and Ph.D. students come to Argonne to do their theses.

Beginning in 1956, Argonne has presented special Summer In-

stitutes to university and high school teachers. About 60 university instructors attended a general course in nuclear science and engineering in 1956, and about 40 attended special Institutes last summer. One Institute covered work in the design and use of training reactors while the second covered methods in techniques of radiobiology. Brookhaven, Oak Ridge, and Ames Laboratories, and Hanford Works have given similar courses.

In 1957 Argonne also presented two Institutes to a total of 41 high school science teachers. These will be repeated in 1958.

Argonne, along with the other laboratories and AEC contractors, has a very large number of visitors, including foreign people.

Supporting Facilities

Argonne is a complete establishment in that it has its own water supply, water purification plant, heating plant, and sewage and waste disposal plant. It normally purchases electrical power, but recently has produced all its own power from nuclear sources in the Boiling Water Reactor part of the time.

In addition to the utilities, Argonne has very extensive machine, carpenter, welding, and varied shops to support the scientific staff. Many machine shop items are purchased outside, but many special items are designed and built at Argone. This includes complex electronic instruments for reactors, research and development work, and computers.

Future of the Laboratory

It is expected that the National Laboratories in the nuclear field will continue in existence and probably continue to expand for a number of years. In respect to nuclear power, they will follow somewhat the history of the National Advisory Committee Aeronautics Laboratories in their role in the airplane industry. The NACA Laboratories are continuing to collect basic design data and to assist in the development of aircraft components.

The AEC laboratories, because of their broader base in research, will probably expand their power reactor work for ten to fifteen years, and then slowly convert over to basic investigations. Argonne is expected to expand its work in the design of very high neutron flux test reactors, accelerators, and possibly fusion reactors.

The physical facilities will be expanded in the immediate future by construction of the facilities outlined in Table I. All of these projects have been approved. In addition, the Laboratory is considering the construction of a very high flux reactor, metallurgy facilities, and other versions of power reactors.

TABLE I

AUTHORIZED CONSTRUCTION

Facility	Estimated Cost
1. Experimental Breeder Reactor II	$29,100,000
2. Fuels Technology Laboratory	10,000,000
3. ARBOR—Phase I	8,500,000
4. Fuel Fabrication Facility	4,000,000
5. Zero Power Reactor Facility	3,200,000
6. Argonne Low Power Reactor	1,990,000
7. Chemical Engineering Cave	867,000
8. 12.5 Bev Proton Accelerator	27,000,000
9. Research Reactor Alterations (higher power level)	380,000
10. Housing	533,000
Total	$85,600,000

In 1948 it became obvious that test and pilot reactors should be built in an isolated area, so Argonne requested that a "proving ground" for reactors be opened. Thus, the National Reactor Testing Station came into being. Argonne presently operates the Experimental Breeder Reactor I, the Boiling Water Test Experiment known as Borax-IV, and a Zero Power Fast Reactor, ZPR-III at Idaho. In addition, Items 1, 3, and 6 will be built at Arco.

The future of the National Laboratories is dependent upon continued financial and moral support by the people of the United States. We have a tendency to demand results from research and development and at the same time not appreciate the people working in these fields. Management and sales people are given greater financial rewards. It is extremely difficult to keep top flight people happy in a laboratory when they see their results taken over by industry and higher salaries paid to the industrial people.

Another difficult problem is that of maintaining an academic atmosphere and at the same time living under an atmosphere of governmental budget control. All the laboratories have frequent seminars and information meetings, and the scientists and engineers are encouraged to attend and take part in frequent scientific meetings. The atmosphere must be one of leisure in which the impetus for rapid work comes from the individual.

Argonne and the other laboratories attempt to pay sufficient salaries and provide retirement benefits sufficient that the scientist and engineer need not be concerned about his income or the stability of his position. Salaries are comparable to, though usually somewhat lower than, industry's in the lower paid positions. In the responsible positions they are very much less than in industry.

Summary

Argonne carries out research, development, and training in all aspects of the nuclear field. Essentially, it is a number gathering institution, since its only product is its formal reports and papers. Its only reason for existence is that the public believes that benefits will come from its work. Certainly we may expect that Argonne and the other nuclear research and development laboratories in the U. S. should be expected to contribute important developments. Nuclear power is, of course, the most significant development now under way. It is expected, however, that the understanding of the life processes will be extremely important in the years to come.

ARGONNE NATIONAL LABORATORY SUMMER PROGRAM

For the second year, Argonne National Laboratory, Lemont, Illinois, will provide an opportunity for high school teachers to review the fundamentals of nuclear energy and to be made aware of the latest developments in this field of science. Four sessions, each spanning a $2\frac{1}{2}$-week period, will be offered.

The courses are tentatively set to run from June 9 through August 27, with final dates dependent on the number of teachers enrolled for each session. Tentative dates are June 9 through 25, June 30 through July 17, July 21 through August 6, and August 11 through 27.

The teachers will hear lectures by Argonne scientists and will perform experiments dealing with physics, chemistry, biology, and metallurgy, all as related to atomic energy.

They will visit such Laboratory facilities as the Experimental Boiling Water Reactor, first reactor in the Atomic Energy Commission's power reactor program to be completed; research reactors; the Argonaut, an atomic reactor designed for college graduate training; and the "iron room," where the radioactive content of humans is accurately measured.

The courses are sponsored by the Argonne chapter of the Scientific Research Society of America. The courses were organized to help narrow the gap between the training of many high school teachers and the current state of scientific knowledge.

Forty midwestern high school and junior college teachers attended the first two courses conducted at Argonne last summer.

Inquiries about the courses should be directed to Dr. Earl W. Phelan, Laboratory Director's office, Argonne National Laboratory, P.O. Box 299, Lemont, Illinois. Sole expense will be a $10 individual registration fee. Participating teachers will be expected to provide their own housing accommodations in the Chicago area.

Operated by the University of Chicago under contract with the Atomic Energy Commission, Argonne National Laboratory is situated on a 3700 acre tract 25 miles southwest of Chicago. It employs a staff of 2700.

Work in progress covers atomic energy research in several fields: physics, chemistry, biology and medicine, reactor engineering, applied mathematics, chemical engineering, metallurgy, remote control engineering, and electronics.

Also at Argonne National Laboratory is the International School of Nuclear Science and Engineering. The School is operated under President Eisenhower's "Atoms for Peace" program and is the only institution of its kind in the United States. It provides foreign and domestic graduate students and engineers with the opportunity to study the scientific and engineering fundamentals pertaining to the development of atomic energy for peaceful purposes.

SIMPLE CATHODE RAY TUBE APPARATUS

(FIFTH IN A SERIES)

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Certain cathode ray tubes, such as the 3BP1,[1–2] can be operated with focusing and accelerating potentials much lower than those recommended for normal operation. If one takes advantage of this fact, several demonstrations involving the deflection of an electron beam are made available very inexpensively in a simple and convenient fashion.

Figure 1 shows one method of mounting the cathode ray tube. The appropriate socket[2] is attached to the center of an eight inch square of masonite or bakelite. Connections from the socket are made to binding posts or Fahnstock clips[2] arranged as shown in the figure. A support is then provided for this assembly so that the CRT makes an angle of about 10^0 with the horizontal when inserted in the socket.

The simplest possible circuit necessary for operating a cathode ray tube is given in Figure 2. The heater terminals H-H are connected to the secondary of a 5.0 filament transformer.[2] The cathode K and grid G are both connected to the negative terminal B− of a direct current supply. The common connection of the cathode and grid terminals to B− means that the CRT will be operating at full intensity with no grid control, but this is not harmful to the tube if the accelerating potential is kept low. The second or accelerating anode A_2 is attached to the positive terminal B+ of the dc supply. The first or focusing anode A_1 is connected to the center point of a voltage divider consisting simply of two 5 megohm-$\frac{1}{4}$ watt resistors[2] R_1 and R_2 in series. This connection of A_1 does not allow for control of focus, but if the spot is too large its size may be adjusted by using a smaller resistor for R_2. The proper value is best found by trial and then no further focusing control or adjustment is necessary.

The direct current supply should be one of about 300 volts. Several B batteries connected in series or a rectifier-filter combination will suffice. Since the current required for the circuit is very small, the apparatus can be operated for prolonged periods of time.

It must be carefully noted that *all* deflection plates are connected together and that this common connection is terminated on the second anode A_2 in order to prevent stray static voltages between the deflection plates from deflecting the spot entirely off the screen of the CRT.

[1] A cathode ray tube can often be secured very reasonably from dealers in surplus supplies.
[2] These items can be secured from any supplier of electronic apparatus.

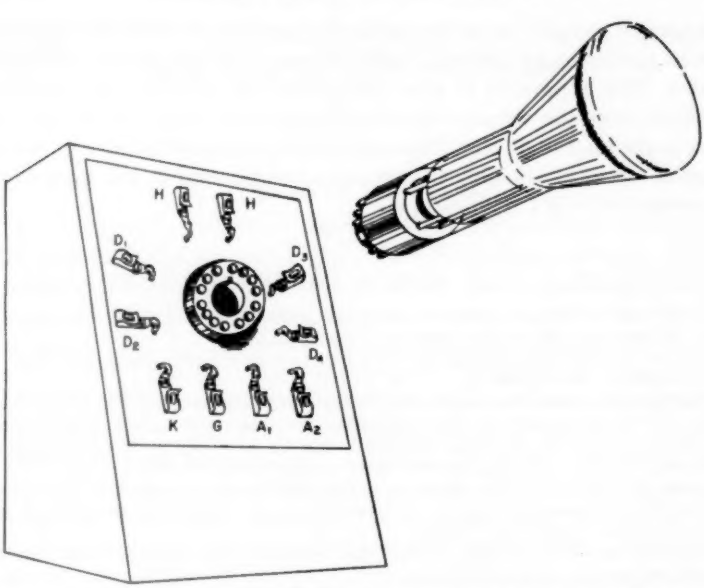

FIG. 1. Sketch showing one method for mounting socket and Fahnstock clip connectors for simple cathode ray tube apparatus.

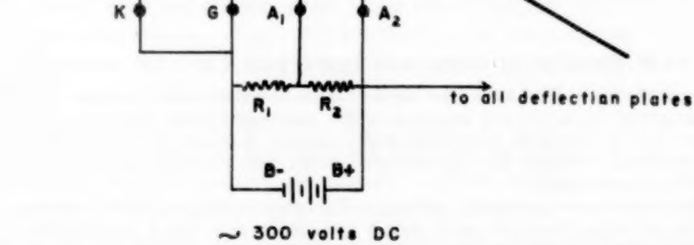

FIG. 2. Diagram showing electrical connections for a simple cathode ray tube apparatus. H-H are heater connections, K, G, A_1, and A_2 are cathode, grid, first anode (focusing), and second anode (accelerating) connections respectively.

Once the beam is established and the spot is seen on the screen, demonstrations of magnetic deflection can be performed by holding a

permanent magnet near the neck of the tube. Electrical deflection can be produced by applying either dc or ac voltages to the deflection plates. The apparatus is also well suited for student self-operated exhibits since the voltages are not dangerously high and the desired effects are easy to obtain. The enterprising student can also be led to suggest circuitry allowing the apparatus to be used in the manner of a commercial CRT oscilloscope.

CASTOR OIL IN DASH BOARDS MAKES CAR DRIVING SAFER

Castor oil in the crash panel of your new automobile will make driving safer and still preserve the interior beauty of your car.

Castor oil as a softening agent is the key to a new foam plastic described as "outstanding" crash padding.

Most plastic foams tried as automobile crash padding have sacrificed maximum safety for better appearance. Scientists have found the best impact shock absorbers to be completely crushable materials with no elasticity or rebound, such as very thick honeycombs of paper or blocks of polystyrene, the light-weight Christmas ornament plastic foam. However, such pads usually are too thick for use on an automobile instrument panel, and would soon be covered by unsightly dents from everyday knocks and bumps.

Thinner flexible pads that do not dent permanently, such as foam rubber, simply do not absorb impact shock.

Allied Chemical and Dye Corporation, Buffalo, N. Y., reported a successful compromise in the form of a castor oil-softened diisocyanate plastic foam. The new padding has enough stiffness to absorb fully nearly all instrument panel bumps encountered in most auto accidents. However, the scientists reported, enough flexibility is built into the new foam to allow it to return quickly to its normal shape after being dented.

Besides making possible superior crash padding, the new castor oil-diisocyanate formulations can also be used as adhesives with higher bonding strength than any other known material, or as protective coatings with outstanding resistance to chemicals and abrasives.

Urethan, an isocyanate blown into a multi-celled foam by gases released when the ingredients react, is used in some present auto crash pads. The properties of the new castor-oil softened derivative surpass those of urethan and are far superior to those of other plastics.

NEW RESEARCH SUPPORTS HOPE FOR CANCER VACCINE

New evidence that a vaccine against human cancer may become a reality sometime in the future was reported by the American Cancer Society.

Dr. Alex B. Novikoff, Albert Einstein College of Medicine, Yeshiva University, has made rats resistant to a transplanted cancer with cell material that, by itself, does not cause cancer.

The work has no practical application to human cancer at present, however.

The antigenic material used, which apparently acts like a vaccine, was extracted from a deadly transplanted tumor that tunnels through tissues, spreads rapidly to distant parts of the body and kills the rat in five to seven days following inoculation. The material was spun out of the cancer cells and comprises less than six per cent of their mass.

It completely protected seven of eight animals inoculated with live cancer 14 weeks after injection of the cell material. All "unvaccinated" controls died of cancer on schedule.

PLANS FOR THE REORGANIZATION OF COLLEGE PREPARATORY MATHEMATICS*

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THE NEED FOR REFORM

In August of 1955, the Commission on Mathematics met for the first time in Ann Arbor, Michigan. It was commissioned by the College Entrance Examination Board to study the college preparatory program in mathematics and to make recommendations to the College Board for strengthening the mathematics program in the secondary schools. After having investigated the program now in existence and the desirability of establishing a more modern program in the high schools, the Commission has made some tentative decisions pertaining to the modernization of secondary school mathematics.

The Commission on Mathematics is not the only group to give thought to curriculum problems. The Committee on the Undergraduate Program of the Mathematical Association of America received its charge from the parent organization just prior to the activation of the Commission. The Secondary School Curriculum Committee of the National Council of Teachers of Mathematics came into being during the year 1955. Since then similar groups in high schools and colleges have been appointed to make studies at local levels.

All of this committee activity, springing from various national and local sources, could only mean that there is a general dissatisfaction with the program of the first fourteen grades and that educators feel it is time to act. The climate of opinion seems to forecast that a change is desirable, in fact, it is necessary. Many agree that modern developments in mathematics and logic should have had an effect on the elementary and secondary program of our schools. Up to this time modern developments have not influenced the programs of the common schools. Saunders MacLane, when asked to write about the effects of modern mathematics on secondary mathematics, made this startlingly clear when he said, "My subject is vacuous; the modern lively development of mathematics has had no impact on the content or on the presentation of secondary school mathematics." While it was not the occasion for him to say so, MacLane's remark could have been directed with almost as much truth, and force, at the undergraduate program in the colleges. The fact is that our programs for training scientists have been too long neglected by everyone; including the mathematicians.

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* A paper presented at the convention of the Central Association of Science and Mathematics Teachers Friday, November 29, 1957. Congress Hotel, Chicago, Illinois.

It was in this frame of reference that the Commission on Mathematics set to work. There is little need to recite the story of the early attempts to find a working combination and an approach to the problem. Needless to say, these problems have been adequately solved and the Commission has been able to tentatively formulate its position as regards the high school program. At this time, it will not serve our purpose to go into the sociological, educational, and philosophical backgrounds for the position taken by the Commission. This will be set forth in its final report. For the present, it would seem that a brief survey of the program envisioned by the Commission would be of considerable interest to teachers of mathematics.

The Dimensions of Reform

Educators recognize that the reform of the college preparatory program is at least a three dimensional effort. In the one dimension a new and more vital type of mathematics must be brought into the curriculum. The mathematics in the schools of today is practically the same mathematics found in the schools of 60 or 75 years ago. In the meantime, mathematics itself has moved forward so rapidly that it has practically lost contact with the program in the schools. For example: today mathematicians consider the concept of set more basic to mathematics than the concept of number. The common schools have not yet recognized this development. Social scientists and biologists could make good use of the elements of set maneuvers, probability and statistical inference, and even the elements of abstract algebra. The common schools have recognized none of these topics either as a part of their formal instructional program or as a part of their "readiness" program for modern mathematics in the colleges.

In the second dimension of this reform effort, one can place those topics and courses that have long since served their purpose. These should be deleted from the program. Our youth must not be required to spend one and one-half years on Euclidean geometry, or some six weeks to half a semester on the computational aspects of trigonometry and logarithms. The days for emphasizing the solution of triangles have long since past. Why prepare our students for the year 1910 when the year 1975 is knocking at our doors?

Located at various points in the plane of the first and second dimension, one will find old topics which must remain in the program, but they must be revitalized by modernizing the language and structuring the ideas. Other topics at other points in the plane need just a little "patching up" and a reordering. For example: the solution of inequalities has always been in the more advanced portions of the mathematics program. It now needs a new point of view, a new orientation, and a new grade placement.

The third dimension of the reform effort is the dimension of depth. The traditional point of view in mathematics fosters a course of study which develops certain algebraic skills such as factoring, solving equations, etc. Too frequently this is the main objective of the mathematics now found in the schools. This has traditionally been the curse of a good mathematics program. Excessive emphasis on the skills of mathematics has debased the subject to the point where it is no longer mathematics. The report of the National Committee on Mathematical Requirements, published in 1923, said. "The excessive emphasis now commonly placed on manipulation is one of the main obstacles to intelligent progress. . . ." This statement is as true today as it was in 1923.

The traditional point of view also fosters the fragmentization of mathematics. In various sections of the country lists of topics to be covered in high school have been and are being circulated by the colleges. One hundred and one topics in a high school course cannot produce the mathematicans we need for 1975. Mathematics is more than a series of topics. It possesses a structure. We need a mathematics in the high school which is a unity. To find this unity we must look to the modern developments in mathematics itself. For example: there is no reason why the basic ideas of a field cannot be used to structure the first year's study of alegbra. If this were done we would have a better algebra course, and a course more readily mastered by the high school student.

But there is yet another aspect of this third dimension of mathematical reform which needs our attention. Solving equations, multiplying polynomials, and calculating the fifth root of 35,469 by means of logarithms do not characterize the work of a mathematician and scientist in the year 1957. Their activities are more closely associated with generalizing, abstracting, and structuring. The mathematician of bygone years was interested in learning how to solve a particular equation or how to find a series expansion for a particular function. Today the mathematician is interested in solving whole classes of problems; problems which at times seem totally unrelated. Today the interest and need is to find the common elements of seemingly totally unrelated situations. In other words, our mathematicians and scientists are interested in the structure and the study of structures.

This present day interest of mathematicians means that they must abstract and generalize. They usually center on solving all equations of a certain type; on finding all solutions possessing a given characteristic; on finding all systems which can be characterized by means of a few statements. In order to produce mathematicians who can do this, we need a mathematics in the high schools which encourages our budding mathematicians, engineers, social scientists, etc., to take

their first steps in abstracting and generalizing. Without this we do not have real mathematics in our schools.

This, in brief, is an indication of the spirit of the revision which the Commission feels should take place in the high school. But what about the actual content—the vehicle which enables the student to experience this spirit of mathematics? A brief description of course content can, perhaps, give you the best feel for how the spirit of a contemporary mathematics can be instilled into the courses in the high school. Let us consider the course content year by year, beginning with the first year of alegbra.

Elementary Mathematics I

From the point of view of actual content, the recommendations of the Commission will not change the course as it now exists a great deal. However, from the structural point of view and from the point of view of the spirit of the course there will be a great difference.

First year algebra should open with a study of sets as a universe of discourse. Statement-forms should then be introduced and the pupil directed to select subsets of the universe in accordance with certain rules. At first, these rules will be simple conditions using a single variable.

All these new words and ideas may be frightening. However, a fifth grader, who knows how to add and multiply, can easily master the fundamental ideas implied by the terms: universe, statement-forms, conditions, replacement instances, and solution sets. It may seem difficult at first because the words are not familiar. Let me assure you that it is easy to master. Ease of learning the new mathematics is one of the main arguments for reorganizing the mathematics curriculum.

This introductory work leads, naturally, to the use of the connectives "and" and "or" which in turn provide a means for the intuitive introduction of the intersection and union of sets. Simple set maneuvers and set symbolism can be introduced at this point if the teacher prefers. (All of this is made "down to earth" for the pupil by relying heavily on graphical techniques.) The work with sets and set maneuvers in the first year of algebra provides a proper foundation for the introduction of probability in the senior year via set considerations.

Once the pupil has the basic concept of a variable in mind, it is possible to get him to accept the postulates of a field as "his own." For example: the commutative and associative laws for addition and multiplication should be developed for the student by relying heavily on his previous experience with replacement instances. Following this, and early in the first year of algebra, the student should be introduced to the kind of argument mathematicians use so much,

namely, proof. Why not ask the ninth-graders to prove that such patterns as $2+x+6=x+8$ and $3 \cdot a \cdot 2=6a$ are valid for all replacements of x? Only the commutative, associative and closure postulates are needed for the proof. Later pupils can be asked to prove that if $3x+1>7$, then $x>2$. This, of course, occurs after the order postulates have been introduced.

Here, then, is a major change in point of view. We prove theorems in algebra just like we prove theorems in geometry. Such an introduction to proof is simpler and more comprehensible to first-year pupils than is the introductory work with deductive methods in the second-year geometry course. Secondary teachers have been too slow in adopting algebraic proofs in first-year algebra as a means for smoothing out the difficulties encountered in a relatively complex situation in geometry.

The recommendation that relations and functions be studied in the first year of algebra is another major departure from usual practice. This work, of course, will be highly informal. It will serve as an admirable background for a more formal definition of relations and functions as sets of ordered pairs in the third year.

Solution sets for conditions in one unknown (equations and inequalities) are found in the first year outline as well as conditions of second degree in one unknown. To introduce the solution of inequalities in the first year is a major departure. There would seem to be no good argument for not doing so. The basic postulates on which the solution of inequalities rest are so similar to those for equalities that it will be little or no additional burden for the student, and their introduction will add immeasurably to the student's understanding of certain mathematics concepts.

The first year's study should be brought to a close with a more formal type of proof. Here the simple little theorems about odd and even integers will provide the necessary content. For example: students can prove that the square of an odd number is always odd, and that the product of an odd and an even number is even.

Elementary Mathematics II

The second year of the mathematics program in the high school should be devoted to the study of geometry. The more notable changes that are likely to be recommended are: (1) The time spent on Euclidean gemetry should be drastically reduced. Rather than spend one and one-half years studying plane and solid geometry, the Commission's recommendations, if followed, are likely to result in about one semester's work in Euclidean geometry. Solid geometry as a course should be abandoned and the more worthwhile aspects of the course should be incorporated in a course covering the geometries for the

secondary school. (2) Synthetic proofs, so common in Euclidean geometry, should not occupy a full year's time for the high school student. By the end of the first semester the Pythagorean theorem should be proved, thereby, enabling teachers to introduce analytical proofs by midyear. From then on synthetic and analytic proofs should be used as convenience and ease of proof dictates. (3) Three dimensional geometry should be introduced in the second year, and a few of the theorems of the geometry on a sphere can be used as foils for certain plane geometry theorems and definitions. It would be well if the study of geometry led the student to see that two lines in space can "never meet" and still not be parallel, or that on some surfaces the sum of the angles of a triangle may be more than 180°. Furthermore, the consideration of surfaces other than the plane would do much for mathematical understanding if students were introduced to the idea that such terms as the "straight line" are not defined. This can be done by showing that there are various interpretations for these terms on surfaces other than the plane.

During this year, the work with deductive arguments will continue. However, the geometry teacher can look forward to students coming to his geometry class who have some acquaintance with direct proof. Hence, this strategy will not consume the amount of time it usually does in the first few weeks of a geometry course. With proof appearing in both first year mathematics and second year mathematics, the wide differences experienced by students between procedures, points of emphasis, etc., as they now exist between geometry and algebra, should vanish. Students should get the idea that algebra, geometry, statistics, and analysis are vitally concerned with deductive arguments.

If one adds to the above recommendations the thought that the high school geometry course should give more serious attention to such things as the difference between direct and indirect proof; converses, contrapositives and inverses; and the introduction of just a few of the more essential ideas of modern logic, then it is readily seen that the geometry the Commission visualizes differs rather markedly from that now in existence in the schools.

Intermediate Mathematics

The third year of the high school program as visualized by the Commission might well be called Elementary Analysis. At this time, a more formal study of some of the concepts introduced and treated rather informally in the first year, will be given serious attention. Among these are: (1) the concept of a relation and a function as a set of ordered pairs, (2) conditions in one and two unknowns (equa-

tions and inequalities), (3) number systems and operations within a system, and (4) transformations of rational and polynomial expressions.

The study of functions will be extended through work with the elementary functions. In addition to the linear and quadratic functions (and simple power functions defined by $y=x^n$), the pupils would study the properties of the logarithmic, trigonometric, and exponential functions. Here again the spirit of the work must change. These functions are often studied in present day programs as a means for computing or solving triangles. Such work is of little importance. The logarithmic function should be presented in such a way that the student obtains a grasp of its basic properties. The logarithmic function is different from any other function presented in the high school. It possesses the property that $f(xy) = -(x) + f(y)$ as well as other interesting and really different properties. These differences should be of more than ordinary interest to the high school pupil at this time in his mathematical development. These properties should impress him as being new, different, and unusual.

In much the same way, the trigonometric functions should be introduced to highlight their periodic properties, not their use for solving triangles. Historically, these functions came about as convenient tools for solving triangles. Today, mathematicicians have lost interest in this aspect of trigonometry. The periodic properties of the trigonometric functions are of utmost importance today. Even the ham radio operator, sitting in the trigonometry class, has much more need for a knowledge of the periodicity of the sine function than he has for its convenience in solving a triangle.

In addition to the study of the properties of the special functions, the third year should include such topics as: (1) exponents and radicals, (2) vectors, and (3) sequences and series.

Advanced Mathematics

The advanced mathematics course for the senior year is, of course, the capstone of the program. Unfortunately, it is often the nadir of our present programs. With one semester spent on solid geometry and a semester on trigonometry, a large portion of which is computational in nature, almost half the senior year is spent with a type of mathematics that is of little value because it is out of the main stream of mathematical effort and interest in this the twentieth century.

At the present time the Commission plans to recommend a rather broad and flexible program for the senior year. In evolving a senior program there is one goal to be held in mind. A four-year high school mathematics course should prepare the pupil for a course in the

calculus during his freshman year in college. Nothing less should be acceptable. With this goal in mind, the senior year has been tentatively outlined as follows.

A group of three semester courses should be offered in the senior year. The first semester must be spent with a course in elementary analysis. Its content should consist of those parts of analytical trigonometry which have not been studied in the third year, a substantial amount of analytical geometry, and elements of the polynomial calculus.

The second course in this group is a full semester course in probability and statistics. In this age when so much appears in our papers and magazines that is statistical in nature, or consists of inferences drawn from incomplete data, the well informed citizen and the technically trained citizen should have a grasp of the fundamental ideas of probability and statistical inference. Drawing conclusions from incomplete data is so common in daily life that schools can no longer neglect this phase of mathematics contribution to the educational welfare of our youth.

There is, of course, a shortage of instructional materials for such a course. This vacuum will be filled by a complete series of units written by members of the Commission. These materials are available in limited quantities at this time. The Commission has published a text in printed form and made it available at a moderate price to those who write in for a copy.[1]

The third course in the senior group is a course in discrete mathematics. At the present time this course has not been planned in detail. One can, however, surmise that the following would be suitable topics for such a course: (1) The elements of logic, (2) finite groups, (3) sets and set maneuvers, (4) vectors and matrices, and (5) modern applications of contemporary mathematics, such as linear programming.

Conclusion

The program that has been outlined for the high school is new and different. This is as it must be. Some will ask, "How can you get this established? Where are the teaching materials? Where are the teachers?"

The Commission has foreseen some of these difficulties. In order to help establish the program in the schools it has embarked on an extensive writing project. Sample units are being written for use in high school classes. These units will not present a complete course (except in statistics), but they will be of sufficient length to illustrate the

[1] Commission on Mathematics, *Introductory Probability and Statistical Information for Secondary Schools: An Experimental Course*. College Entrance Examination Board, 1957.

spirit and the content of the courses. All these materials will be made available to publishers, authors, and teachers. Furthermore, the Commission is in the process of writing expository articles for the teacher. These articles will center around topics which have their roots deep in the secondary program. The primary objective of the articles will be to illustrate profusely the depth and importance of certain mathematical concepts which should be taught in the high schools. The Commission hopes that through units for the pupils, expository articles for the teachers, study guides, and through actual contact with groups interested in secondary education it can establish its point of view. No member of the Commission feels that this will be an easy task and that all will be well in a few years. There is, however, every reason to hope that the situation will gradually change for the better. It is fortunate that the change is likely to be gradual. This gives all of us time to think and it gives us time to adjust to the changes. In any event, the Commission hopes that you will be interested in its activities and it invites you to put your name on a rapidly growing mailing list by writing to the Executive Director, Commission on Mathematics, College Entrance Examination Board, 425 West 117th Street, New York 27, New York.

NOTES ON "CALCULUS: A TRIGONOMETRIC PROCEDURE" BY JOHN J. AEBERLY

George G. Mallinson, *Editor*

In the January 1958 issue of School Science and Mathematics there appeared an article by John J. Aeberly entitled, "Calculus: A Trigonometric Procedure." When the article was received by the editor it was sent to our most able departmental editor of mathematics, Professor Cecil B. Read. Professor Read returned the article with certain strong reservations concerning certain aspects of it. The article was then sent to Mr. Aeberly and returned with certain strong points in its defense. The editor, therefore, *solely on his own judgment*, published the article recognizing that it might evoke controversy. It did!

Hence, in the May 1958 issue of School Science and Mathematics, there will probably appear two articles, one taking a critical view of certain points in the original article, and another by Mr. Aeberly in its defense.

We are pleased to note that we have a critical and objective reading clientele.

CREATIVITY IN THE TEACHING OF ELEMENTARY SCIENCE*

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The word creativity has different meanings for different people depending upon individual points of view and circumstances. Under some circumstances, it may mean the creation or invention of something which has never been made or brought about before, such as the painting of a picture or writing of a poem. In science this would mean the discovering of or the creating of something never before known or made. For others, it may in addition mean putting ideas together to bring about something new to the individual, although not necessarily new to other more experienced individuals. The discovery by children that an electric circuit may be shorted if certain things are done or that air expands where it is heated are examples. Since this article deals with science education at the elementary level, the second understanding is used.

We are hearing a great deal about the importance of science in the world today and about the necessity for training scientists. We will hear increasingly more about the training of career scientists and the part the elementary science teacher plays in helping to develop creative abilities. Career scientists must be creative—they must do that which has never been done before. Children can be expected to be creative to some degree, but they cannot be expected to create the completely new. They are busy learning what is already known in the field of science. It is our job as teachers to help children gain command of sufficient background and to gain it in such a way that they will get experience doing something which in their experience has never been done before. They need the practice and the thrill of putting ideas to work and coming out with new ideas and achievements. Not every child is equally creative, but every child can profit from experience in using the creative abilities which he has.

In general, it can be said that it is constructive to be challenged and to have pressures from external forces put upon any program. Doubtless the pressure for more and better trained scientists is no exception. Certainly there is a great deal of room for improvement in science curricula and in methods of teaching throughout the elementary, secondary, and college levels. There is need for more and better trained teachers. Teachers of self contained classrooms in elementary schools who are expected to teach science need help from trained science people. In many schools, there is need for more and better

* A paper presented at the Annual Convention of The Central Association of Science and Mathematics Teachers, Chicago, Illinois, November 29–30, 1957.

equipment. The science curriculum in most schools needs to be inspected and to be brought up to date. There are times when pressures from outside forces may have a somewhat damaging effect. There is a danger that teachers who have been doing outstanding work in teaching science will be unable to evaluate their work properly and will take the criticism unto themselves. The attempt to improve their techniques and methods might actually cause their work to be less effective. This can easily happen in the area of creativity. Teachers who have been very successful in helping children to develop their creative abilities may actually become less effective by failing to give enough factual background and guidance. Children can no more be creative in the field of science without basic information and equipment than they can paint a picture without paints and brushes. It is the teacher's job to establish the proper balance at each grade level so that children may have opportunities to use reading and writing skills and to handle equipment in building and background which is necessary for more creative work in science.

In the opinion of the author, one of the most essential parts of an elementary science program is that which gives children first-hand experience. Such activities help to give children an opportunity to use ideas and skills and to further develop creative abilities. Such experiences differ widely in variety and values. We are, however, chiefly concerned here with those which give children an opportunity to further their knowledge and to use their creative abilities by experimentation. Individual experimentation is particularly valuable in this respect. The experiments should not be complicated. Those which are most useful for elementary children are not cluttered up with several major concepts but instead involve only one basic principle or idea. The following are some examples:

Air	Plan a way to lift a tin can with a toy balloon.
	Find a way to put a match under water without getting it wet.
Magnets	See how many of the things in this box you can pick up with a magnet. What does this tell you about the things in the box?
	Use two magnets, one of which has marked poles. Determine which of the poles of the other magnet is N. See if you can plan another way to see which of the poles is N.
Electricity	With one dry cell, a small light bulb, and one piece of insulated wire, find out how to make the lamp bulb light up.
	Show in any way that you choose that iron, brass and copper is each a good conductor of electricity.
Sound	Plan an experiment to show that pitch is different than loudness and softness.
Light	Show in any way you choose that light travels in a straight line.
	Show in any way you choose that sunlight may be broken into colors.

Plants	Plan a way to show that plants need sunlight in order to grow.
	Plan a way to show that the amount of chlorophyll a plant has is in some way determined by the sunlight it gets.

The difficulty which many teachers face is to find a way to organize the class so that each child will have an opportunity to use the available equipment without a waste of time on the part of other children. Many times the size of classes or the lack of equipment makes carrying out a program of individual experimentation extremely difficult. For many situations, the following may serve as a good suggestion. Experiments designed either by the teacher or students may be written or typed on cards. Each of the cards may be arranged in a box or on a tray. Along with the card in the box or tray may be placed the necessary equipment. If the class size is small enough and the equipment sufficient, the entire class as individuals may move from one experiment to another. As each experiment is completed, it can be shown to the teacher for checking. If the class is large, the plan just described may be followed but only a small part of the class can be permitted to do the experiments at a time. Other class members will need to be engaged in other worthwhile activities. Some of them may help the teacher with the checking. However, this takes careful planning.

In some class rooms, teachers may find it more desirable to follow a plan similar to that just described and to have copies of experiments for each child. In such cases the results of the experiments may be written. If the results are to be written, the wording of the question should be such that a sufficient answer would be one sentence or a small drawing.

The wording of these experiments may make the difference between giving the child the opportunity to be creative or not to be creative. There follow two lists of phrases which are often used at the beginning of a sentence introducing an experiment. One list is much more acceptable from the standpoint of creativity than is the other.

Find a way to . . .	Lay the bar magnet . . .
What do you predict will . . .	Look for . . .
What does this experiment . . .	The experiment shows . . .
In any way you choose show . . .	In this way show . . .

Every one of these beginnings, both those on the right hand and those on the left, is acceptable at times and in its place. It is possible, however, that more often teachers begin their sentences in the way illustrated on the right hand side than in that shown on the left. Most of us need to make more use of those on the left.

It might be helpful to illustrate as follows: Let us suppose a fourth grade class is doing some work with magnets. The children have an opportunity to do some experiments on an individual basis. The

teacher has prepared boxes which have materials for experiments in them. One box contains a bar magnet and about three dozen paper clips. The experiment card may read

> Lay the bar magnet flat down on the paper clips, and then pick it up again. You will see where the magnet is the strongest.

Or it could read

> Plan a way to show where a magnet is the strongest.

The second reading gives children a chance to use their own initiative whereas the first tells the child almost everything.

It is important that children be told enough, or helped to acquire enough information, that they can pursue activities on their own with satisfaction. It is important too that they have an opportunity to use their own imagination and initiative. The left hand side of the page in every case indicates some possibility that the children will have an opportunity to use their own creative abilities. The right hand column in every case might result in too much teacher direction.

Not all experimentation should be individual. Much of it can advantageously be demonstration. Many times children become so involved in the manipulation of the equipment that they lose sight of the purpose. The choice of a few words on the part of the teacher may here again make the difference between imagination and initiative on the part of the children or the lack of it. The left hand column contains suggestions for phrasing which will cause children to think in a much more creative way.

What question do you . . .	The next question . . .
What will be the next thing . . .	Next we will . . .
If you do this experiment, what will you . . .	If you do this experiment, you will need . . .
What would you suggest . . .	I suggest you . . .
What could we use instead of . . .	We could use a . . .
How much will we . . .	We will need . . .

There are other kinds of first-hand activities which enable children to further develop their creative talents. Planning and making bulletin boards, setting up displays, and making charts or dioramas to illustrate certain ideas are a few of them.

Children have a natural interest in science. The nature of the science content makes it possible to give children many opportunities to be creative. Elementary science teachers are not expected to turn out finished scientists—they are expected to give children the opportunity to acquire suitable content backgrounds and to give them experiences that will be a good foundation for doing scientific research and for making creative contributions.

HIGH-SCHOOL SCIENCE BACKGROUNDS OF COLLEGE FRESHMEN

Clem W. Thompson
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From the secondary schools of our country come students with diverse backgrounds in all areas of instruction. In the area of science this is true more than in any other subject-matter area. Practically all secondary-school students have had four years of work in the area of English but not in the area of science.

The widely diverse science backgrounds of students presents several problems for the college science teacher. He needs to know the general backgrounds his students have had in General Science, Biological Science, Physics, and Chemistry. This information can be used to good advantage for sectioning the laboratories. Students who have not had laboratory experience in any high school science course are at an obvious disadvantage when competing with students who have had an extensive laboratory program. Readings and assignments need to be planned with these differences in science background in mind. Also this information could be utilized in more thoroughly teaching the basic science concepts.

This study includes entering college freshmen who were preparing to become elementary and secondary teachers in the various subject-matter areas of English, Physical Education, Social Studies and others. Many of these students would be teaching science directly or in an integrated manner. Gaps in the science background of these students are more serious than for the average college student because it might well result in poor science teaching of future elementary and/or secondary school students. Obviously, a teacher is not going to teach or will teach poorly science concepts which he does not completely understand. This report deals with a three year study of entering freshmen classes, 1954–56, in the School of Education at Boston University involving 475 students, two hundred twenty-three women and two hundred fifty-two men. Roughly eighty per cent of the students were graduates of secondary schools within a radius of fifty miles of Boston, Massachusetts. Other students were largely from adjacent New England states and New York City.

A short questionnaire form, on a 4 by 6 card, was given each student the first meeting of a General Biology course. On this form the student indicated all of the science courses he had completed in secondary schools. Additional information in relation to laboratory experiences, school size, school year courses were completed was indicated. A laboratory was defined as a learning situation in which the individual class members performed the experiments, individually or in groups.

It was found that Biology, Chemistry, General Science and Physics, in the order listed, were taken most frequently by students in this study. A summary of the courses taken by the students is shown in Table I. Chemistry and Physics were taken more frequently by men

TABLE I

MEN AND WOMEN SECONDARY SCHOOL SCIENCE COURSES

Subject	Men		Women		Men and Women	
	No.	%	No.	%	No.	%
Biology						
Course	176	70	199	89	375	79
Lab.	101	58	147	74	248	66
No. Lab.	75	42	52	26	127	34
No Course	76	30	24	11	100	21
Chemistry						
Course	165	65	124	56	289	61
Lab.	132	80	117	94	249	86
No. Lab.	33	20	7	6	40	14
No Course	87	35	99	44	186	39
General Science						
Course	147	59	140	63	287	60
Lab.	57	39	43	31	100	35
No. Lab.	90	61	97	69	187	65
No Course	105	41	83	37	188	40
Physics						
Course	120	48	17	8	137	29
Lab.	90	75	13	76	103	75
No Lab.	30	25	4	24	34	25
No Course	132	52	206	92	338	71

than women but a higher per cent of women took General Science and Biology. Approximately 9 out of 10 women had a high school Biology course. More men than women took Science courses but the difference is largely due to many men taking Physics.

Laboratory experiences vary greatly with the courses. In Physics and Chemistry eight out of ten students have had laboratory experience. Two-thirds of the students have had a laboratory experience in Biology and in General Science approximately one-third.

A most important question that could not be answered in a study of this type is the quality and extent of the laboratory experiences. Equipment, facilities, class schedule, and the training of the teacher are important factors in this regard. In general students from larger schools had less laboratory experience.

Comparisons of the three different entering freshman classes did not reveal any general trend of an increasing number of students taking science courses (Table II) with the exception of Physics where there was a yearly increasing number of men taking this subject.

The greatest change in the per cent of students taking any science

TABLE II

CLASS AND SEX DIFFERENCES IN SECONDARY SCHOOL SCIENCE COURSES

Year	Biology				Chemistry				General Science				Physics			
	Men		Women		Men		Women		Men		Women		Men		Women	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1958	58	72	64	90	40	49	48	68	52	64	52	71	35	43	7	10
1959	53	61	96	88	66	76	54	49	43	49	60	54	42	48	8	7
1960	65	77	39	95	59	70	22	53	52	62	28	68	43	51	2	4

courses occurred in Chemistry where it increased from 49% to 76% of the entering men then fell off slightly to 70% the next year. No explanation is offered for this great increase.

The number of students who have taken high school Chemistry and Physics is considerably higher than the figures reported in other similar studies.

It can be said safely that there does not seem to be any evidence of an overemphasis of science courses taken by the secondary school students in this study (Table III). An increasing mean number of

TABLE III

MEAN NUMBER OF SCIENCE COURSES TAKEN BY SECONDARY SCHOOL STUDENTS

	1958		1959		1960	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
Men	81	2.3	87	2.4	84	2.6
Women	71	2.4	111	2.0	41	2.2

science courses for men students is evident in Table III. On the other hand there is a slight mean decrease for women.

CONCLUSIONS

The following conclusions are evident:

1. Biology was taken by more students than any other high school science course.
2. One-third or more of the students had no previous high school course in General Science, Physics, and Chemistry.
3. Many students have had no laboratory experiences.
4. Introductory college science courses will be initial science courses for 30% or more of the students. (Exception: Biology—20%)

THE SCHOOL CAMP—A PART OF THE TOTAL CONSERVATION PROGRAM*

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Children come to us and to their school life equipped with limited experiences and with varying attitudes. As they mature and live more extensively at home, in the community, and at school their value judgments become more sound, and they begin settling into some of the attitudes which will become a part of their total personalities and will contribute to their permanent characters.

School camping is generally founded upon the idea that there are some things which are learned more thoroughly and easily in a natural setting than in a classroom. Certainly, conservation is one of those areas of learning. Children of present-day society exist for the most part in an urban and semi-urban society, and unless schools provide a curriculum which will acquaint children with natural surroundings to demonstrate men's dependence upon nature's basic cycle many, many children may never experience this important aspect of living.

A "readiness" for the understanding of conservation principles may be developed very well in the classroom. *The Pioneer*[1] by Arthur Guiterman, is an example of a poem which lends itself well to the development of appreciation for the primeval forests and the profusion of wildlife that our country once possessed. *Buffalo Dusk*[2] by Carl Sandburg causes one to feel a sharp loss when he reads the lines telling of the buffaloes' going.

The school camp provides almost endless opportunity for the teaching of facts about conservation. Thus the Laboratory School of Indiana State Teachers College has established this activity as a part of the curriculum for the middle grades. A week of each year is spent at Camp Bradford Woods, a 2200-acre tract of land located near Martinsville, Indiana. It is located about sixty-five miles from Terre Haute. It has been observed that distance from family tends to offset homesickness and too frequent parent visitation. Much "growing up" has been observed in the camp situation.

Prior to actual camping experience the children plan every activity and regulation which will characterize their camp. Two to three months are required for such planning, and it is done by student committees and faculty. The objectives of the school camp are explained to parents and other interested persons.

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* A paper presented at the Annual Convention of the Central Association of Science and Mathematics Teachers, Chicago, Illinois, November 29-30, 1957.

[1] May Hill Arbuthnot, *Time for Poetry* (Scott-Foresman), p. 181.

[2] *Ibid.*, p. 182.

Routine matters of insurance, permission slips, and transportation facilities are cared for early by the teacher. A camp bank is established which is operated by a staff of students supervised by their teacher. A fee of $15.00 is charged each student, and the savings bank gives an opportunity for children to save toward their camp fund.

Upon arrival at camp, children are assigned cabins and they put away their personal things and make their own beds. Much help is required at the first effort. However, it has been noted that independence soon follows as group relationships are established.

Menus are planned in advance by the students and faculty. Students participate in such culinary activities as peeling potatoes, scraping carrots, and other duties of table setting, serving, clearing tables, washing and drying dishes.

The daily program is challenging and exciting. Children go about their duties quickly and efficiently and are soon ready for the day's work. A typical day at camp is shown below.

DAILY TIME SCHEDULE

INDIANA STATE TEACHERS COLLEGE LABORATORY SCHOOL CAMP
CAMP RILEY

6:00	Alert group serving breakfast
6:15	Alert all other groups
6:15– 7:00	Wash, dress, clean cabins and grounds
7:00– 7:15	Raise the flag
7:15– 8:00	Breakfast
8:00– 8:40	Inspection and preparation for activity
8:40	Trumpet signal
8:40– 8:45	Muster
8:45–11:00	Morning activity
11:00–11:30	Take pictures, make diary entries, and prepare for lunch
11:30–12:45	Lunch and group singing
12:45– 1:45	Rest on bunk
1:45– 2:00	Prepare for afternoon activity
2:00	Trumpet signal
2:00– 2:05	Muster
2:05– 4:45	Afternoon activity
4:45– 5:00	Lower the flag
5:00– 5:45	Shower and make diary entries
5:45– 6:45	Dinner
6:45– 6:55	Free time in cabins
6:55	Trumpet signal
6:55– 7:00	Muster
7:00– 8:00	Campfire
8:00– 8:45	Square dance
8:45– 9:00	Change into night clothes and eat snack
9:00	Lights out

Children are restricted to one piece of luggage and a bed-roll. Required materials for each camper are shown below.

List of Supplies

2 small sheets or 1 large
1 blanket
1 pillow

Personal

3 pair jeans
Blouses or shirts
jacket
adequate underclothing
rain coat
1 pair old shoes
1 pair good shoes (optional)
pajamas
Girls bring one dress or sweater and skirt

Toilet articles

two towels—2 wash cloths
1 bar soap
toothbrush—paste
comb
creams and hair dressing as needed

Miscellaneous

1 spiral notebook
2 pencils
1 flashlight
2 wire hangers
2 dust rags
1 apron

List any allergies

In summary it can be said that school camping is based on the belief that there are some things taught in school which are learned more readily in the out-of-doors. Among these are:

1. Understanding of the balance in nature.
2. Recognizing the vastness and majesty of the universe and the mysteries of forests and streams.
3. Observing and utilizing the resources in nature for beauty and economy.
4. Learning such things as to estimate distances, rate of speed, to draw figures to scale, use a compass, et cetera.

There are considered to be other and less tangible learnings that grow in a camp atmosphere. Perhaps these are of even greater importance, if possible, than those just listed:

1. Sharing of responsibility.
2. Doing work for joy of accomplishment.
3. Making new friends.
4. Understanding teachers better.
5. Learning to appreciate application of safety rules, rules of conduct, and social groupings.

The school camp meets a real need of present-day children, and it

provides experiences which many of the children will get in no other situation.

ACTIVITY SCHEDULE

INDIANA STATE TEACHERS COLLEGE LABORATORY SCHOOL CAMP
CAMP RILEY

Tuesday Afternoon	Groups I and II	Gather reeds, dig clay, explore the stream, and study the compass
	Groups III and IV	Forest trail and sandpits
	Groups I and II	Campfire
	Group II	Serve dinner
Wednesday Morning	Group II	Serve breakfast
	Groups I and II	Crafts
	Groups III and IV	Clay, reeds, stream, compass
	Group III	Serve lunch
Wednesday Afternoon	Groups I and II	Forest trail, sandpits
	Groups III and IV	Crafts
	Groups III and IV	Campfire
	Group IV	Serve dinner

Special grouping

*(All children participating)

Thursday Morning	Group I	Serve breakfast
	Sycamore Creek Group	Hike to Sycamore Creek
	Gold Creek Group	Crafts
	Group II	Serve lunch
Thursday Afternoon	Sycamore Creek Group	Crafts
	Gold Creek Group	Hike to Gold Creek
	Group III	Serve dinner
Friday Morning	Group IV	Serve breakfast
	All Children	Evaluation, recording, photographing, and sharing

* Grouped by physical stamina for hikes of different length.

DISNEY SCIENCE FILMS NOW AVAILABLE FOR EDUCATIONAL SHOWING

Two nationally-acclaimed Walt Disney films dramatizing science and engineering are now available on long-term lease to schools and industry:

"MAN IN SPACE."—Runs 30 minutes, tells the story of rockets and the part they will play in space travel. (For schools: $300 on 10-year lease. For industry: $350 on 6-year lease.)

"OUR FRIEND THE ATOM."—Runs 47 minutes, explains basic atomic theory and the peaceful challenge of the atom. (For schools: $350 on 10-year lease. For industry: $400 on 6-year lease.)

No admission may be charged at showings of the 16 mm. sound films. Prospective film-leasers west of the Mississippi should write: Walt Disney Productions. Educational Film Division. 2400 West Alameda Ave., Burbank, Calif. East of the Mississippi: Walt Disney Productions. Educational Film Division, 477 Madison Ave., New York, N. Y.

THE RELATIVE DIFFICULTIES OF DIFFERENT TYPES OF ITEMS ON TESTS FOR HIGH SCHOOL SCIENCE*

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INTRODUCTION

Throughout the history of education in general, and of science education in particular, the problem of effective evaluation has been one of the most perplexing faced by teachers. The importance of this problem has been pointed out in a number of recent NARST reports and discussions.[1,2,3,4,5,6]

All these reports point out the fact that much research still needs to be done with respect to the methods for measuring satisfactorily students' abilities to use scientific method and to apply science principles, and possession of scientific attitudes.

In an attempt to obtain pertinent information it was decided to analyze carefully a few selected items from a series of high-school science examinations. These items have been studied from the viewpoint of the type of question represented; the "popularity" of the item with students; and their relative degrees of difficulty. It is hoped that such an analysis may reveal some facts that will prove helpful to high-school science teachers in their teaching and evaluation.

BACKGROUND OF THE STUDY

The data used in this study were gathered as part of a major investigation,[7] portions of which have been presented at earlier NARST meetings.

In order to clarify the techniques and findings of this study, it will be helpful to outline briefly the research design used in the major

* A report delivered at the Thirtieth Annual Meeting of the National Association for Research in Science Teaching at the Hotel Claridge, Atlantic City, New Jersey, on February 15, 1957.

1 Mallinson, George Greisen and Buck, Jacqueline V., "Some Implications and Practical Applications of Recent Research in the Teaching of Science at the Secondary-School Level." *Science Education*, XXXVIII (February 1954), 58–81.

2 Anderson, Kenneth E., Smith, Herbert A., Washton, Nathan S., and Haupt, George W., "Second Annual Review of Research in Science Teaching." *Science Education*, XXXVIII (December 1954), 333–65.

3 Smith, Herbert A., Washton, Nathan, Mallinson, Jacqueline Buck, Boeck, Clarence, and Fraser, Thomas P., "Third Annual Review of Research in Science Teaching." *Science Education*, XXXIX (December 1955), 335–71.

4 Boeck, Clarence H., Mallinson, Jacqueline Buck, Hubler, Clark, Reiner, William B., and Weaver, Edward K., "Fourth Annual Review of Research in Science Teaching." *Science Education*, XL (December 1956), 337–57.

5 Mallinson, Jacqueline Buck, "What Have Been the Major Emphases in Research in Elementary Science During the Past Five Years?" *Science Education*, XL (April 1956), 206–8.

6 Smith, Herbert A., Mallinson, Jacqueline Buck, Boeck, Clarence H., Branson, Herman, and Fraser, Thomas P., "Symposium: Needed Research in Science Education." *Science Education*, XL (December 1956), 363–77.

7 Mallinson, George Greisen and Buck, Jacqueline V., "An Investigation of the New York State Regents Examinations in Science." *The Journal of Experimental Education*, XXIV (September 1955), 43–89.

investigation. The purpose of the earlier investigation was twofold: (1) to investigate the attitudes of certain science teachers from the State of New York toward the New York State Regents Examinations in Science, and (2) to analyze and evaluate certain characteristics of the Regents Examinations for Biology, Chemistry, Earth Science and Physics prepared for the examination periods of January 25, 1949; June 21, 1949; January 24, 1950; and June 20, 1950.

Among other characteristics, the individual items appearing on each of these sixteen examinations were analyzed with respect to their reliability, consistency, validity, popularity with students, degree of difficulty and discriminatory power. In order to make such analyses, it was necessary to item-analyze each individual item appearing on the sixteen examinations studied. A total of 31,317 examination papers were analyzed. The entire investigation involved nearly 30,000 man-hours of work, and over 1,500,000 entries on tally sheets.

The Regents Examinations in Science are composed of two parts, Part I consisting of fifty short-answer items (all of which must be answered by the student); and Part II consisting of eight or nine essay-type items (of which the student must answer five). Since a student has the option of "rejecting" certain Part II-items, it is possible to compare the "popularity" of certain types of items. This was done by determining the percentage of students electing to answer a given test item. If thirty per cent (or less) of the students elected to answer an item, it was considered to be "unpopular." If seventy per cent (or more) elected an item, it was considered to be "popular."

All these Part II essay questions (each bearing a total point value of ten) are composed of two to ten parts of varying point values. In order to determine the degree of difficulty of these items, the percentage scores were computed by dividing the total number of points earned by all the students answering the item by the total number of points that they could have earned had they all answered it correctly.

It is with these two characteristics, namely, popularity and relative degree of difficulty that the study reported herein deals.

METHODS

Since Part I of each of the examinations studied consists of fifty short-answer items, all of which must be answered by the student, it was impossible to make a determination of "popularity" of these items. Further, it was found that the vast majority of these Part I items measured only factual recall. Hence, it was decided to limit this study to an analysis of Part II items only.

Copies of each of the sixteen examinations described above were then analyzed carefully. On the bases outlined earlier, specific test

items exemplifying "popular," "unpopular," "difficult," and "easy" items were selected. These were then studied and compared in an attempt to trace certain significant patterns with respect to the objectives measured by the item, students' selection or rejection of it, and its relative degree of difficulty. The discussion of the selected items follows.

Findings

Biology Items

The following two essay-type items appeared on the *same* Regents Examination in Biology (January 25, 1949):

"5. A report appeared in a newspaper that someone had 'discovered' cancer to be caused by bacteria. This report was challenged at once by scientists and thoroughly disproved.
   a. Where did the reported bacteria probably come from if not from the cancer tissue? State the error in technique that was responsible for the appearance of the bacteria.
   b. Name the scientist who gave us a technique still used today to determine whether a certain bacterium is the cause of a definite disease.
   c. What *four* established procedures could have been used to determine whether bacteria cause cancer?
   d. Name *three* approved methods used in the modern treatment of cancer."

"9. *a.* What is the function of each of *four* of the following parts of a flower: (1) anther, (2) ovary, (3) ovule, (4) petals, (5) stigma?
   b. State *one* similarity and *one* difference between a polar body and a mature egg cell.
   c. Describe the difference between sexual and asexual reproduction. State a biological advantage of *each* method to the species."

Item 5 above was the only one classified as "unpopular," while number 9 was the only one categorized as "popular." It is somewhat difficult to measure "popularity" precisely because the failure of a student to select a given item is not necessarily an indication of unpopularity. Often the better students answer the items in order, 1, 2, 3, 4, 5—omitting the last two or three items on the test. However, in the case of number 5 above, one may assume that it is a relatively unpopular one, since it appears in the middle of the examination and still was rejected by the vast majority of the students. They demonstrated a preference for 9 by skipping to the end of the examination to answer it.

From even a superficial analysis, one may easily see that item 5 tests the student's ability to *apply* facts and principles, while number 9 merely measures factual recall. It is interesting to note that the two items are of approximately the same degree of difficulty, judging by a comparison of their percentage scores. However, it would appear that students (even the better ones) avoid items that require them to *apply* their knowledge, rather than simply regurgitating it.

The following two items (from the Jan. 24, 1950 Biology Examina-

tion) were also found to be unpopular with the majority of the students:

"8. *a*. A boy without a microscope wants to find out if there are bacteria on his fingers.
(1) What is a culture medium and how is it sterilized?
(2) List *two* important steps in his experiment following this sterilization.
(3) What would indicate the probable presence of bacteria?
(4) What evidence would he require to justify a conclusion that the bacteria had come only from his fingers?
b. Consider an imaginary situation—a world without bacteria.
(1) State and explain *one* way in which the food supply would be affected.
(2) Name and state the cause of *one* disease not caused by bacteria."

"9. There are three types of radishes: round, oval and long. A breeder made the following crosses, with the results indicated below.
First cross: long with round gave 342 oval
Second cross: long with oval resulted in 48 long and 52 oval
Third cross: oval with round resulted in 141 oval and 137 round
a. What type of inheritance is indicated here?
b. Using letters, show the gene makeup of long, round and oval radishes. Supply a *key*.
c. Using keyed and labelled diagrams, show the cross between (1) long and long radishes, (2) long and round radishes, (3) oval and round radishes."

The unpopularity of both of these items may, of course, be partially explained by the fact that they are the last two on the examination. Hence, one may assume that some of the students failed to answer them simply because they had elected the required five items in order, thus eliminating those at the end of the test. However, in light of the large percentage of students who "rejected" these two items given above, it would indicate a desire on the part of some of them to avoid the item-type.

A review of these two items indicates that once again they require more than mere factual recall. Some knowledge of and application of scientific method is called for. It was found, upon a review of percentage scores, that items 8 *a* (4) and 9 *a* (above) were particularly difficult for the students electing these items. Hence, it would appear that "thought-type" items are difficult for students.

Each of the following items appeared on the June 21, 1949 Examination in Biology. While there was no definite pattern of popularity or unpopularity detected within these selected items, each one of them was considered to be difficult, judging by their comparative percentage scores:

"Tell whether . . . the following is *true* or *false* and give your reasons.
1. Poison ivy can be destroyed by pouring salt water on its roots." (2 *b* 1).

"Write a brief explanation of . . . the following facts.
d. The bones of elderly people are more brittle than those of children." (3 *d*).

"Give a scientific explanation for . . . the following statements.
3. There are far more color-blind men than there are color-blind women.
4. Giant varieties of flowers have been produced experimentally by the use of chemicals." (4 *a* 3, 4).

"The crane is a bird with long legs. This enables the bird to feed in shallow water.

(1) Tell how Darwin might have explained the development of the modern crane from a short-legged ancestor." (5 *a* (1)).

"Give a biological explanation for . . . the following statement(s).

b. Apple growers find that the same kind of spray becomes less effective year after year." (9 *b*).

Once more it may be noted that all of the above items might be called "application-type" items; that is, they require more than mere factual recall. They require that the student *apply* the scientific facts and principles learned, and they point out the relationship of biological facts to everyday life. Judging from the percentage scores, this type of response is apparently difficult for most students.

The following item was classified as the most unpopular one appearing on the June 20, 1959 Biology Examination:

"6. *a*. Give *two* reasons why making habits of routine activities helps to make us more efficient.

b. Students may fail at school because of poor study habits. How would you apply any *three* rules of habit formation to the establishment of good home-study habits?

c. Select *two* of the following and state *two* effects on the body for each case selected: (1) an increase in the amount of adrenin, (2) an overproduction of thyroxin, (3) a lack of insulin.

d. How does the secretion of a ductless gland get into the blood stream?

In addition to being the most unpopular item on this examination, part *c* was one of the most difficult items on the test. Once again, one may conclude that test items requiring the ability to apply knowledge and discern relationships are the ones that give the students the most trouble.

The item listed below, even though it was number 1 on the June 20, 1950 examination, was of "medium-low popularity." Part *b* of this item was particularly difficult for the poorer students, though the good students did well on it.

"1. *a*. State the observation and a possible conclusion for *each* of the following experiments:

(1) For several seconds a girl blew through a straw into limewater in a beaker.

(2) A boy chewed a soda cracker for several seconds, placed the chewed cracker in a test tube, added Fehling's (or Benedict's) solution, then boiled the contents.

(3) The cut end of a fresh stalk of celery was left for several hours in a beaker of red ink, then several cross sections of the stalk were made.

b. Describe a simple control experiment that must be set up for parts (1) and (2) above before you can reach a final conclusion."

In summary, then, it would appear that the thought-type items—those requiring application of facts and principles—are both unpopular and difficult for the majority of the students taking the Regents Examinations in Biology studied in this investigation.

Chemistry Items

The following three items were selected from the January 25, 1949

Examination in Chemistry. Item 7 that follows was the most unpopular one on the test and a review of the percentage scores indicated that it was moderately difficult for most students:

"7. *a*. Describe a process for making ethyl alcohol from molasses.
b. Name a by-product of this reaction. Give a use for the by-product.
c. Describe the manufacture of soap, mentioning the raw materials, the use of salt, and the by-product.
d. Name *two* processes used in the manufacture of gasoline from petroleum. Describe *one* of these processes."

Item 6 below was taken from the same examination. It was categorized as "medium-low" popularity, and part 6 *d* was particularly difficult.

"6. *a*. Starting with limestone, tell how you would make (1) quicklime, (2) slaked lime.
b. You are given a supply of limewater and a source of CO_2 gas. Tell how you would prepare a sample of temporary hard water.
c. Why is sodium carbonate effective in the softening of permanent hard water?
d. Describe the preparation of bleaching powder.
e. Tell briefly how to prepare acetylene."

Item 8 that follows was of average popularity, but parts *a* (4) and (5) were of a high degree of difficulty.

"8. *a*. Give the purpose of the use of sulfuric acid in each of *three* of the following:
(1) Cleaning metals for electroplating
(2) Manufacturing concentrated sulfuric acid by the contact process
(3) Manufacturing nitric acid
(4) Making superphosphate fertilizer form phosphate rock
(5) Making esters
b. How do the products differ when H_2S is burned in (1) a limited supply of oxygen (2) an excess of oxygen?
c. Why must superheated water be used in the Frasch process to melt the sulfur?"

An analysis of these three items seems to indicate that in chemistry, as in biology, students have difficulty with items that require them to *apply* their factual knowledge. In these, as in ensuing selected items, one can detect a pattern indicating that there is difficulty when commercial uses and applications of chemistry are called for.

The most unpopular item on the June 21, 1949 Chemistry Examination was item 6, that follows:

"6. *a*. Give an example of *each* of the following: (1) a carbohydrate, (2) a hydrocarbon, (3) an ester, (4) an organic acid.
b. Write the structural (graphic) formula for (1) chloroform (2) ethylene.
c. Name *two* products which are obtained from coal tar.
d. State *one* use for each product mentioned in *c*."

In the above item, parts 6 *a* (3); 6 *b* (1), (2); 6 *c*; and 6 *d* were all difficult for the students.

Item 8 that follows was a "medium-low" popularity item from the June 21, 1949 examination. On this item, parts *b*, *d*, and *e* were especially difficult for students.

"8. *a*. Name *three* chemical properties that nitric acid has in common with most acids.
b. Name *one* chemical property that nitric acid has in common with hot concentrated sulfuric acid.
c. Name *two* commercial methods by which ammonia may be made.
d. Give the reagents used in the laboratory preparation of (1) nitric oxide, (2) ammonia.
e. Ammonia water gradually loses its strength on standing in an open vessel. explain.

Once more one may conclude from these examples that the ability to synthesize facts, draw implications, and see relationships are the characteristics that students seem to lack.

This inability to apply facts is seen again in the following difficult item taken from the January 24, 1950 Chemistry Examination.

"Give *one* chemical reason why a farmer occasionally treats soil with slaked lime." (7 *e*)

The field of organic chemistry also appears to be a difficult area for many students. This is reflected in the following items from that January 24, 1950 examination. While these items were of average popularity, they all proved to be difficult for the students who elected them.

"6. *a*. Draw the structural formula of (1) methane and (2) benzene.
b. Define a carbohydrate.
c. How is acetylene prepared?
d. What is meant by fractional distillation?
e. Describe *one* method of making methyl alcohol.

There appeared to be only one unpopular item on the June 20, 1950 Chemistry Examination. It was number 7 that follows:

"7. *a*. Describe how to make acetylene.
b. Name *two* uses of carbon dioxide.
c. (1) Give *two* important raw materials used in the manufacture of carborundum. (2) State *one* outstanding property of carborundum.
d. Briefly describe how you can produce carbon dioxide from (1) coal, (2) marble chips, (3) a solution of molasses."

Even though the above item was unpopular, it was only of average difficulty. On the basis of the content of this and other unpopular items, it may be hypothesized that such items requiring a knowledge of uses and commercial applications of chemistry are avoided by students.

This is reflected once more in the following,item from the same test (June 20, 1950). In this one, which was of medium-low popularity, parts *b*, *c*, and *e* were especially difficult.

"8. *a*. In the extraction of iron from its ore, limestone, coke and hematite may be used. Give a reason for the use of each.
b. A test strip of aluminum was exposed to the air for several years. Explain why the aluminum showed little corrosion.
c. Define metallurgy.

d. Name an alloy composed of (1) copper and zinc, (2) tin and lead.
e. What metal is always present in an amalgam?"

Earth Science Items

It is interesting to note that ***no unpopular*** items were revealed in the analysis of the four Earth Science Examinations. It is, of course, impossible to give an objective explanation of this situation. However, it is possible that this is due to the fact that a much smaller number of students take Earth Science than is the case with the other science fields. In all probability, those students who do take the course are the ones who are most interested in it, and hence do well. It would appear that such a student population would have fewer "unpopular" items than a more diverse group.

There were very few "difficult" items on any of the Earth Science Examinations, also. The following three items, however, were categorized as difficult:

"In New York State the altitude of the noon sun is higher during the summer than it is during the winter. Explain." (January 25, 1949, 5 *b*)
"When it is 11 A.M., June 22, in the eastern standard time belt, what is the ***hour*** and ***date*** at Sydney, Australia (150° east longitude), and the ***hour*** and ***date*** in the Azores Islands (20° west longitude)?" (January 25, 1949, 6 *d*)
"Air descending the side of a mountain becomes compressed. Why does this make the air comparatively dry?" (January 24, 1950, 6 *c*)

In these "difficult" items, as with the difficult Biology and Chemistry items, it may be seen that the answers require some thought and application of facts, rather than factual recall only.

Physics Items

On the Physics Examinations, as with the Earth Science Examinations, there were relatively few "difficult" items. Here again one may hypothesize that one possible reason for this is the fact that a fewer number of students elect physics than biology and chemistry; and those who do elect it are the better students. In addition, all of the items categorized as "unpopular" were the last two items appearing on any one test. This also is characteristic of the responses of good students, who generally answer the items in order, omitting the last ones on the test. Hence, the higher numbered items may ***appear*** to be "unpopular."

Of the physics items studied, the following were both unpopular and of moderate difficulty:

"8. Give an explanation based on physical principles for each of ***five*** of the following:
a. A charged storage battery is less likely to freeze than a discharged one.
b. Speaking into the mouthpiece of a simple telephone transmitter causes a pulsating direct current in the transmitter circuit.
c. When there is no current in the wire, a compass needle is parallel to the

wire. However, when there is current in the wire, the compass needle is perpendicular to the wire.

d. A "pith" ball is first attracted and then repelled by a negatively charged rod.

e. A coil of wire is connected to a galvanometer. Moving the coil in the air may cause the galvanometer needle to be deflected.

f. Two lamps labeled "150 watts-120 volts" and "25 watts-120 volts" are connected in series to a 120-volt source. The 25-watt lamp develops heat at the greater rate." (January 25, 1949)

"8. Give an explanation based on physical principles for each of *five* of the following:

a. When a negatively charged rod is brought near the knob of a negatively charged electro-scope, the leaves spread farther apart.

b. Shears used to cut sheet metal have longer handles than those used to cut paper.

c. Snow partially covered with dirt and soot melts more rapidly in sunlight than does clean snow.

d. Brass is a good metal to use in constructing compass cases.

e. When the external circuit is connected, a force of 10 pounds is required to rotate the armature of a generator. When the external circuit is disconnected, this force is considerably reduced.

f. The larger specific gravity readings are found at the bottom of the hydrometer scale." (June 21, 1949)

Once again in these physics items, as in the other subject-matter areas, it appears that items requiring an application of facts and principles are the ones that are the greatest "stumbling blocks" for students.

There is often much discussion among science educators concerning the relative degrees of difficulty of physics problems. In an attempt to collect some data related to this question the problems appearing on the four Physics Examinations under study were analyzed. Interestingly enough, there appeared to be about as many ***popular, easy*** problems as ***unpopular, difficult*** ones. The following examples represent items that were both easy and popular:

"6. A step-up transformer used to operate a neon sign has a turn ratio of 1:100. The primary voltage is 110 volts. The primary current is 10 amperes. The secondary current is .09 ampere.

a. Find the secondary voltage."

"*c.* Find the wattage of the secondary.

d. Find the efficiency." (January 25, 1949)

In contrast, the following problems were difficult for the majority of the students:

"Find the number of calories needed to change 1 kilogram of ice at 0°C. to water at 20°C." (4 *c*, January 25, 1949)

"A 1-lb. stone dropped from the bridge strikes the water 2 seconds later. Find (4) the kinetic energy possessed by the stone the instant it strikes the water." (2 *b* (4), June 20, 1950)

"Find the fundamental frequency in vps. of a note produced by a whistle, closed at one end, if the length of the air column is 6 inches. Air temperature is 20°C." (4 *c*, June 20, 1950)

Obviously, no sweeping generalizations may be drawn from such a small number of cases, but it does appear that mathematical problems are not as great a "stumbling block" to physics students as many teachers have been led to believe. In addition, students apparently do *not* avoid such problems as much as they avoid the "application-type" items, for *no* mathematical problems appearing on the four Physics Examinations studied were categorized as "unpopular."

Summary

In this study an attempt was made to detect significant patterns with respect to the "popularity" and relative degrees of difficulty of selected items appearing on sixteen New York State Regents Examinations in Biology, Chemistry, Earth Science and Physics. In general, this analysis seems to indicate that in all subject matter areas, the items that give students the most difficulty are those requiring an application of facts and principles; those that call for an understanding of the applications of science in everyday life. In all four areas such items proved to be both difficult and unpopular.

There were fewer unpopular and difficult items on the Earth Science and Physics Examinations than was the case with Biology and Chemistry. It may be hypothesized that this is due, at least in part, to the fact that fewer students elect these courses and those who *do* elect them are in general the more able ones.

From the findings in this study, it would appear that science teachers might well spend more time in an attempt to help students understand the importance of scientific facts and principles in our daily lives, and to developing in them the ability to extend and apply the knowledge they gain through their study of science. In short, teachers must help students understand relationships, rather than merely becoming "walking encyclopaedias" of scientific facts.

1958 SECTIONAL MEETINGS OF THE ILLINOIS COUNCIL OF TEACHERS OF MATHEMATICS

The Illinois Council of Teachers of Mathematics, in cooperation with host institutions and school administrators, is again sponsoring a series of sectional meetings during the spring months.

The programs of these meetings are planned to include current problems in teaching of elementary and secondary school mathematics. There are principal speakers at general sessions and then discussion groups are used for more specific problems. All teachers of arithmetic and other phases of mathematics are urged to take this opportunity to keep abreast with the happenings in the field of mathematics. You are encouraged to write to the sectional chairmen to get detailed information or to give suggestions concerning the meetings.

Three meetings were held in March. These were at Belleville on March 15; at Hinsdale on March 22; and at Western Illinois University, Macomb, on March 22. Three additional sectional meetings will be held in April. Information concerning these is as follows:

Wednesday, April 16

Eastern Illinois University, Charleston

Principal Speakers:	
Secondary Section	Dr. K. B. Henderson University of Illinois
Elementary Section and also speaker in evening	Dr. Nathan Lazar Ohio State University
For additional information contact the Sectional Chairman	Dr. Charles E. Pettypool, Jr. Eastern Illinois University Charleston

Saturday, April 19

Southern Illinois University, Carbondale

For additional information contact the Sectional Chairman	Dr. Dilla Hall Southern Illinois University Carbondale

Saturday, April 19

Illinois State Normal University, Normal

Principal Speakers:	
	Dr. Donovan A. Johnson University of Minnesota "Concepts We Should Teach Every Mathematics Pupil"
	Dr. Phillip S. Jones University of Michigan "Interrelationships Throughout Mathematics"
	Miss Alice M. Hach Racine, Wisconsin "Extending Concepts in the Junior High School"
For additional information contact the Sectional Chairman	Miss Elinor B. Flagg Illinois State Normal University Normal, Illinois

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An advance notice of the Annual State Meeting of the Illinois Council of Teachers of Mathematics is made at this time.

Saturday, October 4, 1958

Aurora

Theme: "Mathematics in a Space-Minded Era"

For additional information contact	Mrs. Donna Holroyd, President Illinois Council of Teachers of Mathematics 1600 28th Street Rock Island, Illinois
or	
	Dr. Francis R. Brown, Chairman of Publicity Illinois Council of Teachers of Mathematics Illinois State Normal University Normal, Illinois

INDUSTRIAL DEMONSTRATIONS IN SCIENCE CLASSES*

B. Fagginger-Auer
Goodyear Atomic Corporation, Portsmouth, Ohio

Newspapers and magazines have been devoting a great deal of space to articles on the need for more scientists and technicians in this country. "We need more technologists in the work force," one editor says. "We need more science teachers at all levels. We need more physical facilities, school buildings, laboratories. One step below the professional level, we need more skilled technicians. Also, we have to make sure we fully utilize the scientists and engineers we now have" (1).

Although a few dissenting writers have tried to argue that the present need for well-qualified and capable people is temporary, most authorities insist that it is both urgent and permanent. Those of you who may have been associated with industrial concerns during the past few years are undoubtedly aware of the demand for good scientists and engineers. Although many industrial concerns offer the latest in materials and equipment, spotless working conditions, excellent safety records, and other ideal facilities which should attract proficient science graduates in large numbers, these inducements alone do not seem adequate to attract sufficient numbers of our best youth. We must make every effort, therefore, to accentuate the attractiveness of scientific careers.

You teachers here assembled, being keenly aware of the need for high caliber scientists, are deeply disturbed over another situation. You and your colleagues continue to wrestle with the decline of enrollment in high school science courses. I am sure we all agree that this trend must be recognized, stopped, and reversed. Let us briefly examine a few ideas as to how this might be accomplished.

Even though educational specialists have the know-how required for an attack on the problem, they are frequently hampered by inadequate funds. Industrial organizations, unfortunately, are rarely able to donate funds directly. However, the many scientifically trained individuals associated with these firms do feel a real responsibility to share their experience and knowledge. Science can be appealing, and people in scientific fields can help you to impress this upon the minds of American youth by bringing to the schools their own enthusiasm for the adventure to be found in their work. They can also help you give them a realization of the opportunities offered by scien-

* Presented to the General Science section of the Central Association of Science and Mathematics Teachers at Chicago, November 30, 1957.

tific careers. Beyond this the opportunities in science as you define them to the students will have to stand upon their own merit.

In accord with the democratic ideals of our nation, educators can only guide students into training as future scientists. A student must be able to make his own free choice of vocation. Working together, and with the help of well-informed members of society, you in education and we in industry eventually may succeed in persuading more of today's youth to embark upon scientific careers.

You may well ask, what has actually been done and what is now proposed to implement the theories that have been set forth above? Ralph L. Dannley (2), who spoke to this session in Chicago last year, emphasized the use of the lecture-demonstration method for enriching the early general science courses. He spoke further of the help which industry is able and willing to give to the schools. A. P. Burruss (3), of the Texaco Research Center, has outlined a program which has been developed for presentation to teen-age and adult audiences. You have all read of the traveling exhibits and visiting teachers coming from the Oak Ridge Institute for Nuclear Studies. Such programs are encouraging youthful scientists all over the nation. We technically trained employees of Goodyear Atomic are among the many interested individuals attempting to bring such a program to the schools in a local area. Although our program is neither novel nor unique, I do believe you will appreciate my sharing with you our experiences of the past few years.

In order that you may understand our program in its proper setting I will briefly describe the local area in which our company operates as well as say a few words about our plant and its function. Ours is the newest of the three huge gaseous diffusion plants, the other two being at Oak Ridge, Tennessee, and Paducah, Kentucky. Goodyear's purpose in the Atomic Energy Commission program is to operate this complex plant which must separate the isotopes uranium-235 and uranium-238. Southern Ohio was selected as the site of the gaseous diffusion plant because of the available manpower, adequate water supply, and several other factors. The location is midway between Chillicothe and Portsmouth, each about 25 miles distant. The plant site is therefore fairly remote, well away from any villages, business establishments, or other industrial organizations. In this area, therefore, Goodyear employs the majority of the technically trained people who could be the source of help to the local schools.

Original construction of our facilities caused considerable concern on the part of the local population. What had been an area of submarginal farms and small scattered villages in the typical hill country of southern Ohio suddenly had to accommodate more than 20,000 construction workers and their families. Trailers and temporary hous-

ing served for several years as the answer to the housing problem. The existing educational facilities were strained to the limit and it was necessary for the federal government to provide additional facilities for the young families who were settling in our area.

Upon completion, the plant was turned over to the Goodyear Atomic Corporation in 1955. The rapid influx of the thousands of construction workers from all over the country and the arrival of operating personnel necessitated a considerable amount of adjustment in the local community. The departure of the construction forces which left only the Goodyear personnel, who would be permanent inhabitants, necessitated further adjustments. During the past few years, the cooperation of many of Goodyear's scientifically trained personnel with the local schools and other community groups has been a significant factor in the smooth assimilation of the newcomers in the local population.

In 1955 a number of Goodyear personnel who were members of the Ohio Valley Chapter of the American Chemical Society collaborated in making plans to help with encouragement of science talent in the local schools. This was in complete agreement with the aims of the Society at the national level. Through contacts made with PTA, school societies, and other neighborhood organizations, the group became aware of facilities as they existed both on a nationwide scale and in the local schools. County and village schools were operating on minimum state salary schedules. Many schools which had been offering laboratory courses were forced to convert their laboratories to full-time academic classrooms. Promising teachers in the sciences were being lured to larger school systems elsewhere. In short, our southern Ohio communities were having to deal with those same problems which continue to plague educators in many other parts of the nation.

Having surveyed the situation, the group selected a committee with a nucleus of former teachers and interested scientists. Suggestions concerning programs were solicited. From these evolved several school visitations for the express purpose of guiding the chemistry and physics students toward further pursuit of science studies in college. Some four or five visits were made during the school year 1955–1956. Each program was received with enthusiastic comment by all authorities concerned. Last year the program was carefully re-evaluated. Recognizing the fact that the majority of graduating high school seniors were not college-bound, we felt that a greater need might be satisfied if the ninth grade level were to be the target of our efforts. Any help which we could give to teachers of older groups by helping with project work or even units of study in chemistry or physics would be earnestly attempted. But our major emphasis in the

program would be aimed at the General Science level. Many industries in the rapidly expanding Ohio Valley Area have need for technicians with terminal high school educations. If we could help to expand the high school enrollment in mathematics, chemistry, or physics, our program would be helpful for the average student and could be considered a success. Promising college-bound students would, in addition, be encouraged in their future studies in science.

Last year we visited seventeen schools in our area. Our total audience was about 3300 students. We have deliberately avoided auditorium-assembly type programs, feeling that intimacy is lost in such a presentation. Instead, we have encouraged audience participation by setting up some twenty or more demonstrations and experiments at the students' desks where they meet during their General Science recitations. Occasionally, additional nonscience classes, not necessarily ninth grades, also participated. Our request was for audiences of about 25 individuals but groups often comprised closer to 50 students.

None of us, of course, can devote a great deal of time to these presentations. I feel this is desirable, since an individual who approaches such a project which is "extra-curricular" to his regular duties does so with a spontaneity which might otherwise be lacking. Our volunteer teams of three men for each trip may include chemists, physicists, engineers, mathematicians, information specialists, and others. The only requisite for participation in the program is genuine enthusiasm and some ability in communicating ideas to youngsters.

Using a team of three men for the presentation accomplishes various purposes. Because of the limited amount of time, and to keep up a rapid-fire patter, it is necessary to have more than one demonstration ready at any given time. If stroboscopic light demonstrations, for example, are more effective in a darkened room, it is desirable to have one person who knows the program stationed at the light switch. This does away with the interruption caused by the oft-heard request for "Lights, please." We also have found that a periodic change from one speaker to another may sometimes compensate for lack of either speaking ability or audience-pleasing personality. Finally, we have found that for one individual, especially for one not trained as a professional teacher, a full day of instructing before a group of students is a tiring job, both physically and emotionally. It is good to have three people who can divide the work.

We feel and emphasize that our project is not an attempt to take the place of the school teaching program, but to supplement it instead. This is our answer to those who would ask, "Why present twenty or thirty experiments superficially, when it would be better to do three or four in greater detail?" Our intention is to whet the scientific appetite of the youngster by exposing him to as many stimulating

experiences as possible in a short period of time. We hope to evoke many questions and arouse a desire for further experiences which can be satisfied only when the student returns to his teacher in succeeding class periods. That these aims are accomplished is evident from unsolicited letters we have received from faculty, students, and school administrators in our area.

Many techniques which contribute to a good learning situation are employed. We divide the class period into four equal parts, three for each demonstrator and one for the students. Since the number of possible demonstrations is greater than can be given in one class period, each of our men is strictly limited to his allotted time. Accordingly, he chooses only those materials which he feels are most pertinent to the age level or interest of the audience. For instance, a group of sophisticated seniors might not be intrigued by simple demonstrations such as the coin-and-forks balance trick. Yet freshmen can and do enjoy watching a cork fisherman balancing precariously on one matchstick leg. With a large number of demonstrations ready for presentation, any item, such as a Wilson Cloud Chamber which fails to work during a particular showing, can be put aside at a moment's notice and something else quickly substituted in its place.

Generally an eye-catching item, such as a phenolphthalein ammonia fountain, is alternated with one less dramatic such as a growing silicate garden. This varies the tempo of the demonstrations and adds more variety. Also, the fact that our demonstrators move about from one desk to another, with the students seated or standing near the sides of the room, demands closer attention by the youngsters.

We conscientiously provide one-fourth of the class time for student participation. During that time they are encouraged to whistle into the microphone attached to an oscilloscope, noting the variations of volume and pitch. They also enjoy other activities such as manipulating the Geiger Counter, or trying out the lucite rod which "bends light around a corner." At such times they usually break up into small groups. Invariably they ask to see or hear more about some of the materials which were used during the formal presentation.

Our ideas for subject matter have been largely gathered from standard methods and materials tried and tested for many years by competent secondary school teachers. The demonstrations and experiments are neither difficult nor profound. We are frank to announce to the youngsters that our apparatus and explanations are kept as simple as possible. This we feel encourages them to repeat these procedures either in school or at home where further learning can occur. In some cases pieces of apparatus such as a three-foot-high Cartesian Diver are used. These are designed to be as large as practical for maximum effectiveness in the presentation.

We also try to vary our demonstrations through the use of different kinds of techniques. The copper plating of an iron nail by immersing it in a test tube of copper sulphate solution is a classical demonstration. We feel that verbal reference to the alchemist who tried in a similar manner to fool the king and lost his head in the process helps the students to remember the principles involved.

Similarly, one might demonstrate the action of a catalyst in the classical manner. But we encourage the student to try this one the next time he goes to dinner when there are candles on the table. He should surreptitiously reach into his father's ash tray and place a bit of cigarette ash on his own cube of sugar. Then he should ask others of the family if they are able to burn theirs. Only he is successful in causing the cube to burst into flame. We must assume, of course, that others who try the same thing are not familiar with the actions of such a simple catalyst.

Some of our demonstrations are expressly chosen for their dramatic value. We have varied the much-used iodine clock experiment by shining a strong beam of light up through a container of mixed solutions. Having previously timed the change of color for exactly ten seconds, for example, we have the students mentally count to ten and snap their fingers to test their sense of timing. In another instance we rely upon surprise. We place a generous-sized piece of dry ice in a can with a tight-fitting lid, utilizing as a safety device a pail carefully inverted over the whole before the class begins. When the can "explodes" the students can well appreciate the pressures exerted by confined gases.

Sometimes the humor of a situation is exploited, but always with the intent of showing a scientific principle or application. We find that a pretty young girl is often more effective as a volunteer than the "football type" who is so often the butt of well-meant humor. We ask the girl to test her strength by blowing through a constricted tube into a round-bottomed flask of water. The object seemingly is to count the bubbles she can blow through the water into the flask. Eventually she gets a faceful of water as a result of the pressure built up inside; and the audience, while laughing at her chagrin, gets a clear picture of how an aerosol container really works.

Humor may also be at the expense of the demonstrator. The students enjoy the apparently ridiculous situation of having one of their members pound spikes into a two-by-four which is supported above a number of dictionaries on top of the visiting speaker's head. The inertia is present in the books but not at all in the reaction of the audience, for this demonstration is one which occasionally has been greeted with spontaneous applause.

Several demonstrations should be mentioned here because of the

interest they arouse simply as "scientific gimmicks." The first uses a 15-inch-diameter "Frenelens," which is a product available through the Bolsey Corporation. The similarity of this plastic lens to a pop recording (without the hole, of course) is so striking that we usually introduce this section with an Elvis Presley routine. The size, weight, cost, and refractive properties of this lens have delighted and amazed physics teachers as well as student audiences. This may well be a piece of equipment which teachers should investigate. It will be a useful tool for stimulating classroom discussions concerning plastics, measurement, mathematics, or optics.

Another gadget of interest is one which we affectionately call our "chemist's light bulb." We suspend a platinum wire through a rubber stopper in an Erlenmeyer flask. A few drops of concentrated ammonium hydroxide are sufficient to saturate the enclosed atmosphere with ammonia. The stopper is removed; the wire is raised to white heat in a bunsen flame and then quickly reintroduced into the flask. The wire continues to glow. If it does cool down we introduce a little air by blowing across the mouth of the flask. The explanation is clear since the ammonia is being oxidized. The students can detect the visible condensation of water droplets on the inside surface of the flask. The platinum, which is acting as a catalyst, is kept glowing by the heat of the reaction and may continue to glow for ten minutes or more.

Other demonstrations which we have found effective might also be mentioned. These experiments are familiar to most teachers; however, if any of you are interested in details of procedure, Kenneth M. Swezey in *Science Magic* gives an excellent explanation (4). All these demonstrations can be used effectively in classroom recitations. They involve principles commonly studied and have practical applications in the home and in industry. Of the demonstrations listed below, only the one concerned with high voltage need be handled by the teacher. The rest could easily be carried out by students in the classrooms.

1. The eccentric wheel "rolls uphill" when it is carefully positioned by the demonstrator.
2. The "water-to-wine" phenomenon utilizes the acid and base reactions with phenolphthalein.
3. The "dancing mothballs" gain or lose buoyancy as they either absorb or release bubbles of a gas.
4. Long chain polymers are formed from sodium silicate and ethyl alcohol.
5. The spark-coil vacuum-leak detector shows the effects of high voltage on Geissler tubes, Crooke's tubes, and fluorescent light bulbs.

6. The "hydraulic elevator" demonstrates the comparative pressures of a column of water and the atmosphere.
7. Clouds are formed and dissipated in a five-gallon carboy to demonstrate that nuclei are essential for the condensation of water vapor.

That we are successful in our efforts to enourage youngsters in scientific endeavors is uncertain. Only a study over a period of years could prove such a contention. Meanwhile some twenty individuals have volunteered, without special remuneration or recognition, to participate in the program, often at great personal inconvenience. Recently, we received a letter from a county school administrator requesting our program for each of ten schools in his system this coming year. In my opinion this is the best expression of appreciation for our program, for he says simply that the youngsters want us back again.

I feel that our program can change as it grows. I hope others may join with us. I know that the personal satisfaction will be worthwhile.

Bibliography

1. *Chemical News*, July–August, 1957, p. 2.
2. Dannley, R. L., "Lecture Demonstrations in General Chemistry for General Science Classes." School Science and Mathematics, 427–431, June, 1957. (As a source of demonstrations, including directions for presentation, this article will be helpful to all science teachers.)
3. Burress, A. P. *Demonstrations in Science.* Beacon, N. Y., Texaco Research Center, 1957. (A complete description is given of 18 demonstrations presented before school-age and adult audiences. The literature references will also be useful to science teachers.)
4. Swezey, K. M. *Science Magic*, New York, McGraw-Hill Book Co., 1952. (This is an excellent sourcebook for a wealth of ideas, most of which can be easily modified for direct use in the science classroom.)

NEW CONCENTRATED MILK

The University of Wisconsin announced plans for public patent on a process for making a greatly improved concentrated sterilized milk—a canned product which will keep its fresh milk characteristics for several months with or without refrigeration.

For the housewife, the new product has several advantages. It can be used like cream on cereals and desserts, or as a beverage, depending upon the amount of water added. In sealed cans it requires only a third as much cupboard or refrigerator space as bottled fluid milk. In a single shopping trip homemakers can pick up enough for a week or month.

For dairymen the new product means broader markets because concentrated milk can be shipped long distances and can be marketed entirely through grocery channels as other canned foods now are. This could substantially reduce marketing and distribution costs. Care of the product in stores is less exacting than for fresh fluid milk.

CASMT PROGRESS REPORT

Louis Panush

President, CASMT, Henry Ford High School, Detroit, Michigan

In conformity with the policy of the present leadership of CASMT to keep the membership informed by periodic reports, to be published in our journal, School Science and Mathematics, of the activities of the Association between conventions, the following brief progress report is submitted.

During December, 1957, your President, empowered by the By-Laws of the organization and by Board resolutions, and in consultation with the Executive Committee, made a number of appointments to the various committees who must implement the policies and carry on the activities of the Association. The following appointments were made:

Nominating Committee

Mr. Allen F. Meyer, Head of Science Department, Mackenzie High School, Detroit, Michigan, *Chairman.*

Mrs. Muriel Beuschlein, Science Department, Chicago Teachers College, Chicago, Illinois.

Mr. Edward Bos, Immediate Past President, Proviso Township High School, Maywood, Illinois.

Miss Glenadine Gibb, Mathematics Department, Iowa State Teachers College, Cedar Falls, Iowa.

Mr. Robert E. Carpenter, 3216 Berwyn Lane, Richmond, Indiana.

At our 1957 convention constitutional changes were made to inaugurate a new plan for nomination and election of officers. The committee will soon notify the membership of the new set-up and ask for suggestions for nominees for the various offices. I am confident that an enthusiastic response by our members will insure the nomination of leaders into whose hands the affairs and future of the Association could be entrusted.

Policy and Resolutions Committee

Mr. Wayne Gross, Laboratory School, Indiana University, Bloomington, Indiana, *Chairman.*

For a 3-year term, to expire in 1960—

Mr. Joseph McMenamin, Oak Park-River Forest High School, Oak Park, Illinois.

Dr. Cecil Read, Mathematics Department, University of Wichita, Wichita, Kansas.

For a 1-year term to replace the President in his unexpired term—

Mr. Paul Klinge, Supervisor of Science, Indiana University, Bloomington, Indiana.

This committee was charged with a specific task for 1958: To analyze the philosophy and aims of the Central Association in order to bring them up to date with modern trends in science and mathematics education. The purposes declared by the Association in the past are too general and, because of their all-inclusiveness, somewhat meaningless in terms of specifics. Therefore, the committee was asked to present in clear and definite statements what CASMT stands for.

In its report to the Board at the 1957 convention, Miss Alice Hach, 1957 chairman of the Policy and Resolutions Committee made the following recommendation which was subsequently approved: "It is essential that definite action be taken by the Board for the advancement and improvement of science and mathematics teaching. We recommend that the report of the Project and Research Committee of November 1956 and all previous reports of this nature be reviewed and considered as a basis for possible action." This will be the second important task of the committee.

In addition, at the open Board meeting symposium, Dr. Milton Pella, a Past President, in discussing the future of CASMT, recommended that our Association take a stand and positive action on:

"1. Teacher certification in science and mathematics.
2. The nature of the curriculum in science and mathematics for the average and superior pupil in the high school.
3. The nature of the types of facilities needed in the high school.
4. The offering of college level courses in the high school.
5. The nature of the content of the present science and mathematics courses."

To take action on these recommendations, a special committee, to be temporarily known as the *Committee on Educational Policies* was appointed whose task it will be 1) to decide what problem needs the most immediate attention and 2) to begin working on the solution of this problem in order to present its thinking, its findings and recommendations first to the Board for consideration and then to the membership for action. This committee is constituted as follows:

Mrs. Marie S. Wilcox, Mathematics Department, T. C. Howe High School, Indianapolis, Indiana, *Chairman*.

Mr. William A. Hill, Naperville High School, Naperville, Illinois.

Mr. Arnold Wendt, Western Illinois University, Macomb, Illinois.

Mr. William E. Jones, Chairman, Science Department, Evanston Township High School, Evanston, Illinois.

Dr. Milton O. Pella, School of Education, University of Wisconsin, Madison, Wisconsin.

At the Board meeting the President was also empowered to appoint a standing continuing public relations committee. It will be the task of this committee to establish an over-all policy on the Association's public relations and publicity to be guided by not only for the coming convention in Indianapolis but for future meetings and all matters relating to CASMT activities during the year. This committee also will be fully in charge of all magazine, press, radio and TV publicity for the 1958 convention. It is constituted as follows:

Dr. Newton G. Sprague, Consultant in Science and Mathematics' Public Schools, Indianapolis, Indiana, *Chairman*.
Mr. Neil Hardy, Lincoln-Way Community High School, New Lenox, Illinois.
Mr. R. C. Huffer, Head, Department of Mathematics and Astronomy, Beloit College, Beloit, Wisconsin.
Dr. Elmer McDaid, Director of Exact Science, Division of Instruction, Detroit, Michigan.
Mr. L. F. Van Houten, President, Story and Script, 30 N. LaSalle Street, Chicago, Illinois.
Mr. Joseph Kennedy, University of Wisconsin—Milwaukee, Wisconsin.

Acting on a Board resolution, the President also appointed the following to the *Place of Meeting Committee* whose responsibility it will be to choose and recommend the city where the 1959 and possibly the 1960 conventions of CASMT will be held:

Mr. Robert L. Price, Joliet Junior College, Joliet, Illinois, *Chairman*.
Mr. Arthur Reynolds, Northern High School, Detroit, Michigan.
Mr. Hobart Sistler, J. Sterling Morton High School and Junior College, Cicero, Illinois.

We are very fortunate indeed that our good friend and active CASMT member, Mr. James Otto (Washington High School, Indianapolis, Indiana) has accepted the very important task of General Chairman of Local Arrangements. The office is in most capable hands and Mr. Otto will do more than his best to assure the success of the convention.

Professor Clyde McCormick, our most enthusiastic Vice President, has been "on the job" every day since the closing of the 1957 convention planning and organizing the program for the Indianapolis convention. He is evaluating last year's program, sampling the membership for preferences and suggestions, consulting with our leadership—

in order to bring a dynamic and challenging program. He will report periodically, both through the pages of this Journal and by other means, on the highlights and details of the convention program.

We urge our members to let their wishes be known and to write to the chairmen and members of the respective committees regarding the various problems mentioned in this progress report. These suggestions and comments will not only be appreciated but will prove to all of us that our members are deeply concerned with the activities, affairs and future of CASMT and are willing to "stand up and be counted" in these challenging times for science and mathematics education

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HUMIDITY AFFECTS INSECT MORTALITY

Mosquitoes may be more susceptible to a killing dose of DDT when the weather is dry.

In contrast to some earlier experiments, two Indian scientists found humidity has an inverse relationship to insect mortality. Using two controlled humidity levels, approximately 49% and 88%, they found that mosquito pupae grown in the lower humidity were more likely to be killed when exposed to varying doses of DDT as adults. The lethal dose for these mosquitoes also was lower than for those kept at high humidity.

ALLERGIES MAY BE FACTOR IN CHILDHOOD LEUKEMIA

Allergies in mothers and children may be important factor in the development of childhood leukemia.

This has been indicated by an epidemiological study of the cancerous blood disease.

The researchers found that a significantly large number of mothers of children with both leukemia and lymphatic cancer had a history of hay fever, asthma or hives, compared with control groups or with those having other types of cancer. Their children also had a higher incidence of allergy, often appearing as eczema.

NEW DRUG PROMISES PROTECTION AGAINST TB

A new drug that promises to protect man from developing tuberculosis instead of helping to cure the disease after it appears has been synthesized at the Irish Medical Research Council, Trinity College.

The drug, still known by the laboratory label B663, has been shown in experiments with animals to be more effective against the tubercle bacillus than any other anti-tuberculosis agent in present-day use.

Current compounds control TB only when they are administered after the moment of infection. A remarkable thing about the new drug is that even when given to the experimental animal some time before inoculation with the germ takes place, it still exerts its full curative power.

PROBLEM DEPARTMENT

CONDUCTED BY MARGARET F. WILLERDING
San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2594, 2596, 2597. *Richard H. Bates, Milford, N.Y.*

2581, 2594, 2596. *C. W. Trigg, Los Angeles, Calif.*

2574. *Murray S. Klamkin, Lawrence, Mass.*

2599. *Proposed by Brother Felix John, Philadelphia, Pa.*

Solve the equation

$$\frac{x-a}{b}+\frac{x-b}{a}=\frac{b}{x-a}+\frac{a}{x-b}$$

Solution by Julian H. Braun, San Diego, Calif.

Multiplying both sides of the equation by $ab(x-a)(x-b)$ and simplifying yields:

$$(a+b)x^3-2(a^2+ab+b^2)x^2+(a^3+b^3+a^2b+ab^2)x=0,$$

or

$$x(x-a-b)\left[(a+b)x-a^2-b^2\right]=0.$$

Therefore

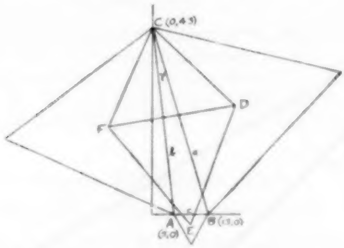
$$x=0, \qquad a+b, \qquad (a^2+b^2)/(a+b).$$

Solutions were also offered by E. W. Bailey, Edinboro, Pa.; Richard H. Bates, Milford, N.Y.; Sam K. Bright, Austin, Texas; J. E. Christian, Oxford, Mass.; A. J. DeGennaro, Kipton, Ohio; Brother Donald, St. Louis, Mo.; Andy E. Forsberg, Billings, Mont.; Ruth Jefferson, Jefferson City, Mo.; H. R. Leifer, Verona, Pa.; J. W. Lindsey, Amarillo, Texas; J. H. Means, Austin, Texas; Frank E. Milne, Halifax, Nova Scotia; J. P. Phillips, Louisville, Ky.; C. W. Trigg, Los Angeles, Calif.; L. R. Wilson, Toronto, Canada, and the proposer.

2600. *Proposed by A. R. Haynes, Tacoma, Wash.*

The vertices of triangle ABC are (5, 0), (13, 0), and (0, 43) respectively. The orthocenters of equilateral triangles constructed externally on the sides of triangle ABC are joined to form the triangle DEF. Compute the radius of the circumcircle of triangle DEF.

Solution by C. W. Trigg, Los Angeles City College



Let D, E, F be the centroids (orthocenters) of the equilateral triangles constructed on sides a, b, c, respectively. Represent angle ACB by y. Then CD and CF make angles of 30° with a and b, respectively. Hence, $CD=a/\sqrt{3}$ and $CF=b/\sqrt{3}$. It follows that

$$\begin{aligned}(FD)^2&=(a/\sqrt{3})^2+(b/\sqrt{3})^2-2(a/\sqrt{3})(b/\sqrt{3})\cos(y+60°)\\ &=\tfrac{1}{3}\left[a^2+b^2-ab(\cos y-\sqrt{3}\sin y)\right]\\ &=\tfrac{1}{6}\left[a^2+b^2+c^2+\sqrt{3[4a^2b^2-(a^2+b^2+c^2)^2]}\right]\\ &=\tfrac{1}{6}\left[a^2+b^2+c^2+\sqrt{3(2a^2b^2+2b^2c^2+2c^2a^2-a^4-b^4-c^4}\right].\end{aligned}$$

Then by consideration of symmetry, $(FD)^2=(DE)^2=(EF)^2$, so DEF is equilateral and its circumradius $R=2/3$ the altitude or $FD/\sqrt{3}$.

In the proposed problem $a^2=43^2+13^2$ or 2018, $b^2=43^2+5^2$ or 1874, and $c^2=(13-5)^2$ or 64. Thus

$$R^2=\frac{1}{18}\left[2018+1874+64+\sqrt{3[[4(2018)(1874)-(2018+1874-64)^2]]}\right]$$

$$R=\sqrt{285.9806} \text{ or } 16.91 \text{ approx.}$$

Solutions were also offered by E. W. Bailey, Edinboro, Pa.; and Julian H. Braun, San Diego, Calif.

2601. *No correct solution has been offered.*

2602. *Proposed by Cecil B. Read, Wichita, Kansas.*

From the top of a scenic incline of uniform slope, the angle of depression of a building on a level plain below is 30°. From a station $\frac{3}{4}$ of the way down the incline the angle of depression of the same building is 15°. Find the slope of the incline.

Solution by Robert A. Atkins, Brooklyn, New York

Let the length of the incline be d and its angle of elevation be θ. Also, let line CE be x. We may then apply the law of sines to triangles DEC and AEC.

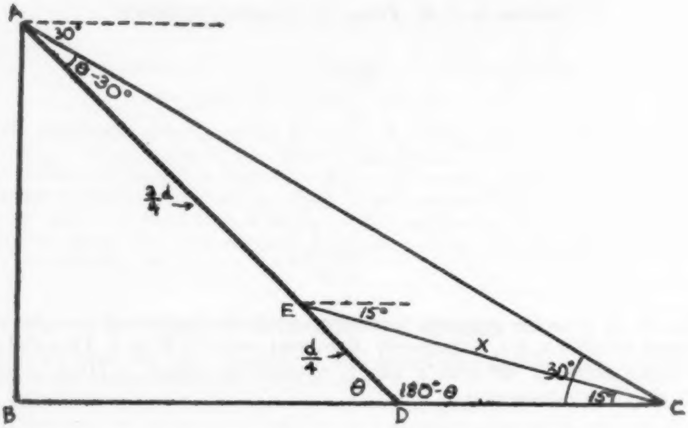
In Δ DEC:

$$\frac{x}{\sin(180°-\theta)}=\frac{\frac{d}{4}}{\sin 15°}$$

but

$$\sin(180°-\theta)=\sin\theta$$

substituting and simplifying the resulting expression gives



$$\frac{4x}{d}\sin 15^\circ=\sin\theta$$

In $\Delta\ AEC$:

$$\frac{4}{\sin(\theta-30^\circ)}=\frac{\frac{3d}{4}}{\sin 15^\circ}$$

simplifying,

$$\frac{4x}{d}\sin 15^\circ=3\sin(\theta-30^\circ)$$

Setting the right-hand members of these two equations equal gives

$$\sin\theta=3\sin(\theta-30^\circ)$$

Using the formula for the sine of the difference of two angles:

$$\sin\theta=3(\sin\theta\cos 30^\circ-\cos\theta\sin 30^\circ)$$

since

$$\sin 30^\circ=1/2 \text{ and } \cos 30^\circ=\frac{\sqrt{3}}{2}$$

$$\sin\theta=\frac{3\sqrt{3}}{2}\sin\theta-\frac{3}{2}\cos\theta$$

multiplying the equation by 2 and rearranging terms gives

$$3\cos\theta=3\sqrt{3}\sin\theta-2\sin\theta$$

$$3\cos\theta=(3\sqrt{3}-2)\sin\theta$$

$$\frac{\sin\theta}{\cos\theta}=\frac{3}{3\sqrt{3}-2}$$

since

$$\tan\theta=\frac{\sin\theta}{\cos\theta}$$

$$\tan\theta=\frac{3}{3\sqrt{3}-2}\quad\text{(slope of the incline)}$$

While the original problem asked for the slope of the incline, its angle of elevation can be computed. The value of θ is approximately $43°11'$.

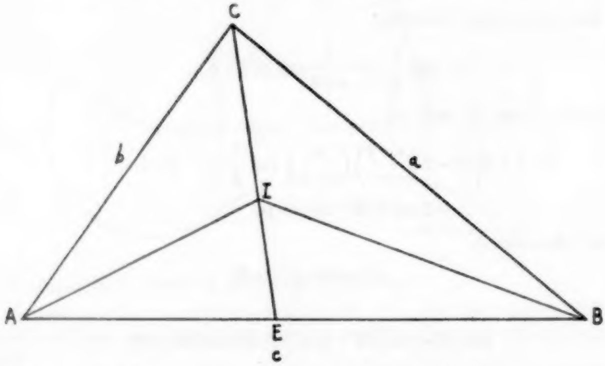
Solutions were also offered by E. W. Bailey, Edinboro, Pa.; Richard H. Bates, Milford, N.Y.; Julian H. Braun, San Diego, Calif.; H. R. Leifer, Verona, Pa.; R. A. Oberhofer, Milwaukee, Wis.; C. W. Trigg, Los Angeles, Calif.; and the proposer.

2604. *Proposed by Mary Reegan, Minneapolis, Minn.*

If angles A and B are acute, prove geometrically that

$$\sin A+\sin B=2\sin\tfrac{1}{2}(A+B)\cdot\cos\tfrac{1}{2}(A-B)$$

Solution by Richard H. Bates, Milford, New York



If angles A and B are both acute, they can, without loss of generality be made the angles of a triangle as in the figure. Let CIE, AI, and BI be the angle bisectors of the three angles of triangle ABC.

It can be shown that

$$\text{angle } CEB=90°+\tfrac{1}{2}(A-B) \tag{1}$$

Also:

$$b:a=AE:c-AE$$

since CE is the bisector of angle C.

From which:

$$AE=\frac{bc}{a+b}\quad\text{and}\quad EB=\frac{ac}{a+b} \tag{2}$$

Applying the law of sines twice to triangle ABC:

$$\sin A=\frac{a\sin C}{c}\quad\text{and}\quad\sin B=\frac{b\sin C}{c}$$

Adding:

$$\sin A+\sin B=\frac{(a+b)}{c}\sin C \tag{3}$$

From the formula for the sine of twice an angle:

$$\sin C=2\sin\tfrac{1}{2}C\cdot\cos\tfrac{1}{2}C$$

Substituting in (3):

$$\sin A+\sin B=2\left(\frac{a+b}{c}\right)\sin \tfrac{1}{2}C\cdot\cos \tfrac{1}{2}C \tag{4}$$

Now applying the law of sines to triangle CEB:

$$\frac{\sin \frac{1}{2}C}{EB}=\frac{\sin \frac{1}{2}\sphericalangle CEB}{a}$$

Making substitutions from (1) and (2):

$$\sin\frac{1}{2}C=\frac{EB\sin\frac{1}{2}\sphericalangle CEB}{a}=\frac{ac}{a+b}\cdot\frac{\sin\frac{1}{2}[90^\circ+\frac{1}{2}(A-B)]}{a}$$

But:

$$\sin\tfrac{1}{2}[90^\circ+\tfrac{1}{2}(A-B)]=\cos\tfrac{1}{2}(A-B)$$

and this last expression becomes:

$$\sin\frac{1}{2}C=\frac{c}{a+b}\cos\tfrac{1}{2}(A-B) \tag{5}$$

Substituting from (5) into (4):

$$\sin A+\sin B=2\left(\frac{a+b}{c}\right)\left(\frac{c}{a+b}\right)\cos\frac{1}{2}(A-B)\cdot\cos\frac{1}{2}C$$

$$=2\cos\tfrac{1}{2}(A-B)\cos\tfrac{1}{2}C \tag{6}$$

One last relationship:

$$\tfrac{1}{2}C=90-\tfrac{1}{2}(A+B)$$

So:

$$\cos\tfrac{1}{2}C=\cos[90^\circ-\tfrac{1}{2}(A+B)]=\sin\tfrac{1}{2}(A+B)$$

Substituting this in (6) gives the required result:

$$\sin A+\sin B=2\cos\tfrac{1}{2}(A-B)\cdot\sin\tfrac{1}{2}(A+B)$$

Solutions were also offered by E. W. Bailey, Edinboro, Pa.; Benjamin Greenberg, Brooklyn, N.Y.; John Reegen, Minneapolis, Minn.; and Walter R. Warne, St. Petersburg, Fla.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

The Student Honor Roll for this issue appears below.

2596. *Lee H. Mitchell, New Trier High School, Winnetka, Ill.*

2599. *Martin Hirsch, Bellmore, N.Y.*

2599. *Phillip Strottner, Serra High School, Gardena, Calif.*

2599. *Edward Budd, Cranford, N.J.*

2599. *William Porcher Jr., Foreman High School, Chicago, Ill.*

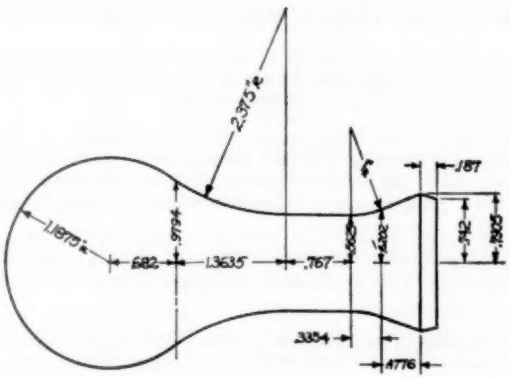
2599. *Alan Zame, Coral Gables High School, Coral Gables, Fla.*

2599. *Robert M. Schwarcz, Coral Gables High School, Coral Gables, Fla.*

PROBLEMS FOR SOLUTION

2617. *Proposed by V. C. Harris, San Diego, Calif.*

Find to the nearest tenth square inch the surface area of the light bulb with cross section given in the figure. The bulb is symmetrical with respect to its axis and open at the base. Assume all curves are line segments or circular arcs. (Figure courtesy Corning Glass Co.)



2618. *Proposed by Richard H. Bates, Milford, N.Y.*

(a) Construct a line parallel to one side of triangle ABC which will intersect the other two sides and bisect the area of the triangle. Let such a line be called a *mediad.*

(b) Show that the three mediads of a triangle form three equal parallelograms and three equal trapezoids.

(c) Let a diagonal of each of the parallelograms of part (b) be called an *intermediad.* Show that an intermediad is parallel to a side of the given triangle.

(d) If the triangle in the center of triangle ABC formed by the three mediads be called the *mediadic triangle*, show that the area of the mediadic triangle is $(17-12\sqrt{2})/2$ times the area of triangle ABC.

(e) Show that the centroid of the mediadic triangle is also the centroid of triangle ABC.

2619. *Proposed by M. Klamkin, Lawrence, Mass.*

Given an isosceles right triangle. Show how to determine the $\sqrt{2}$ correct to several decimal places by means of a pair of dividers.

2620. *Proposed by O. F. McCrary, Raleigh, N.C.*

A stack of pamphlets is in three piles. The first pile contains $\frac{1}{4}$ of them, the second pile, several fifths of them, and the third pile, 6. What is the total number of pamphlets?

2621. *Proposed by A. Elliott, San Diego, Calif.*

A man has six sons and proposes to divide his fortune among them. The amount has only 6 divisors (including unity) and each son is assigned one of these divisors. Each son will receive an amount equal to one plus the number of numbers having no common factors with and less than the divisor assigned. Further the sum of all the numbers less than that representing the fortune and having no factors

common with it is one less than twice the amount to be divided. How much did each son receive?

2622. *Proposed by Frank Peaslee, Cooperstown, N.Y.*

Find x so that $3x^3+7x^2$ is a square.

EDITOR'S NOTE: THERE IS A NEED BY THE EDITOR FOR SOME GOOD PROBLEMS FOR THIS SECTION.

BOOKS AND TEACHING AIDS RECEIVED

MORPHOLOGY OF PLANTS. by Harold C. Bold, *Professor of Botany, The University of Texas.* Cloth. Pp. xxiii+669. 15.5×23.5 cm. 1957. Harper and Brothers, 49 E. 33rd Street, New York 16, N. Y. Price $8.00.

SECONDARY MODERN SCIENCE TEACHING, Part II—A Report on the Teaching of Science in Secondary Modern Schools, Prepared by the Secondary Modern School Sub-Committee of the Science Masters' Association. Cloth. Pp. vii+168. 13.5×21.5 cm. 1957. John Murray, Albemarle Street, London, England. Price 8S.6D.

EDUCATIONAL TESTING SERVICE ANNUAL REPORT 1956–57. Paper. 96 pages. 15×23 cm. Educational Testing Service, 20 Nassaue Street, Princeton, New Jersey.

CREATIVE LEADERSHIP, The President's Report for the year ending June 30, 1957. Paper. 48 pages. 18×26.5 cm. 1957. The Cooper Union, Cooper Square, New York 3, N. Y.

HOW TO STUDY, by Clifford T. Morgan and James Deese, *The Johns Hopkins University.* Paper. Pp. v+130. 18×25 cm. 1957. McGraw-Hill Book Co., Inc., 330 W. 42nd Street, New York 36, N. Y. Price $1.50.

SECOND REPORT TO THE PRESIDENT, by The President's Committee on Education Beyond the High School. Paper. 26 pages. 14.5×23 cm. 1957. U. S. Government Printing Office, Washington 25, D. C.

SCIENCE CAN BE FUN, by Louis Grant Brandes. Paper. Pp. iv+243. 21×27.5 cm. 1958. J. Weston Walch, Publisher, Box 1075, Portland, Maine. Price $2.50.

BIOLOGY CAN BE FUN, Three Games for the High School Biology Class, by Sister Mary Stephanetta, C.S.S.F. Paper. Unpaged. 21.5×28 cm. 1958. J. Weston Walch, Publisher, Box 1075, Portland, Maine. Price $2.50.

AUTOMATION IN PRACTICE, by S. E. Rusinoff, *Professor of Mechanical Engineering, Illinois Institute of Technology.* Cloth. 261 pp. 14×21 cm. 1957. American Technical Society, 848 E. 58th Street, Chicago 37, Ill. Price. $6.50.

ELEMENTS OF MODERN ABSTRACT ALGEBRA, by Kenneth S. Miller, *Associate Professor of Mathematics, New York University.* Cloth. Pp. vii+188. 15.5×23.5 cm. 1958. Harper and Brothers, 49 E. 33rd Street, New York 16, N. Y. Price $5.00.

HOW TO STUDY MATHEMATICS, by E. Richard Heineman. Paper. 19 pp. 14.5×22 cm. 1957. High Publishing Co., 3015 21st Street, Lubbock, Texas. Price $.50.

PROGRAM PROVISIONS FOR THE MATHEMATICALLY GIFTED STUDENT IN THE SECONDARY SCHOOL, edited by E. P. Vance, *Oberlin College, Oberlin, Ohio.* Paper. 28 pp. 15×23 cm. 1957. National Council of Teachers of Mathematics, 1201 16th Street, N. W., Washington 6, D. C. Price $.75.

BUSINESS MATHEMATICS, 4th ed., by Cleon C. Richtmeyer, *Professor of Mathematics, Central Michigan College, Mt. Pleasant, Michigan*, and Judson W. Foust, *Professor of Mathematics, Central Michigan College, Mt. Pleasant, Michigan*. Cloth. Pp. xii+412. 15.5×23 cm. 1958. McGraw-Hill Book Co., Inc., 330 W. 42nd Street, New York 36, N. Y. Price $5.75.

FUNDAMENTALS OF MATHEMATICS, Revised Edition, by M. Richardson, *Professor of Mathematics, Brooklyn College*, Cloth. Pp. xviii+507. 15.5×23.5 cm. 1958. The Macmillan Co., 60 5th Avenue, New York 11, N. Y. Price $6.50.

SCIENCE, TECHNOLOGY AND SOCIETY, color filmstrip. American Iron and Steel Institute, 150 E. 42nd Street, New York, 17, N. Y. (One copy per school system free on request).

SCIENCE, TECHNOLOGY AND SOCIETY, Teacher's Manual to accompany filmstrip of same title. Paper. Unpaged. 14×21.5 cm. 1957. American Iron and Steel Institute, 150 E. 42nd Street, New York 17, N. Y. Free on request.

REFERENCES AND AUDIO-VISUAL MATERIALS ON IRON AND STEEL. Paper. 66 pp. 14×21 cm. 1957. American Iron and Steel Institute, 150 E. 42nd Street, New York 17, N. Y. Free on request.

HEAT, by Alexander Efron, *Chairman of Physics Department, Stuyvesant High School, New York*. Paper. Pp. v+105. 14×21.5 cm. 1957. John F. Rider Publisher, Inc., 116 W. 14th Street, New York 11, N. Y. Price $1.50.

SOUND, by Alexander Efron, *Chairman of Physics Department, Stuyvesan High School, New York*. Paper. Pp. vii+72. 14×21.5 cm. 1957. John F. Rider Publisher, Inc., 116 W. 14th Street, New York 11, N. Y. Price $1.25.

CREATIVE SCIENCE SERIES, edited by Etta Schneider Ress. Includes the following four books: PLANETS, STARS AND SPACE, by Joseph Miles Chamberlain, *Chief Astronomer, American Museum-Hayden Planetarium*, and Thomas D. Nicholson, *Associate Astronomer*. 223 pp. THE EARTH'S STORY, by Gerald Ames and Rose Wyler, 222 pp. THE WAY OF THE WEATHER, by Jerome Spar, *Department of Meteorology and Oceanography, New York University*, 224 pp. ATOMS, ENERGY AND MACHINES, by Jack McCormick. *The American Museum of Natural History*, 224 pp. All cloth, 20.5×27 cm. 1957. Creative Educational Society, Inc., Mankato, Minn.

OFFERINGS AND ENROLLMENTS IN SCIENCE AND MATHEMATICS IN PUBLIC HIGH SCHOOLS, 1956, by Kenneth E. Brown, *Specialist for Mathematics*, and Ellsworth S. Obourn, *Specialist for Science*, U. S. Department of Health, Education and Welfare. Paper. Pp. iv+44. 15×23 cm. 1957. U. S. Government Printing Office, Washington, D. C. Price $.25.

CONSERVATION EXPERIENCES FOR CHILDREN, by Effie G. Bathurst, *Educational Specialist*, and Wilhelmina Hill, *Specialist for Social Science*, U. S. Department of Health, Education and Welfare. Paper. Pp. vi+192. 15×23 cm. 1957. U. S. Government Printing Office, Washington, D. C. Price $.75.

MORE EDISON EXPERIMENTS YOU CAN DO, by Marjorie Van de Water. Paper. 32 pp. 14×21.5 cm. 1958. Science Service, 1719 N Street, N.W., Washington 6, D. C.

VAN NOSTRAND'S SCIENTIFIC ENCYCLOPEDIA, third edition. Cloth. Pp. vi+1839. 21.5×27.5 cm. 1958. D. Van Nostrand Co., Inc., 120 Alexander Street, Princeton, N. J. Price $30.00.

LIBELLUS DE ALCHIMIA, ASCRIBED TO ALBERTUS MAGNUS, translated by Sister Virginia Heines, S.C.N., *Professor of Chemistry, Nazareth College, Louisville, Kentucky*. Cloth. Pp. xiii+79. 14×21.5 cm. 1958. University of California Press, Berkeley 4, Calif. Price $3.50.

THE FOUNDATIONS OF LIFE SCIENCE, by Mark Graubard, *Professor of Natural Science, University of Minnesota.* Cloth. xii+627. 15×23 cm. 1958. D.Van Nostrand Co., Inc., 120 Alexander Street, Princeton, N. J. Price $6.50.

PALMER'S FIELDBOOK OF MAMMALS, by E. Laurence Palmer, *Professor Emeritus of Nature, Science and Conservation Education, Cornell University.* Cloth. 321 pp. 11.5×19 cm. 1957. E. P. Dutton and Co., Inc., 300 4th Avenue, New York 10, N. Y. Price $3.75.

WATER FOR AMERICA, The Story of Water Conservation, by Edward H. Graham and William R. Van Dersal. Cloth. 112 pp. 16.5×23 cm. 1956. Oxford University Press, 16–00 Pollitt Drive, Fair Lawn, N. J. Price $3.50.

THE AIRCRAFT INDUSTRY, by Henry T. Simmons, No. 94 in Vocational and Professional Monographs. Paper. 32 pp. 15.5×23 cm. 1958. Bellman Publishing Co., P.O. Box 172, Cambridge 38, Mass. Price $1.00.

SCIENCE TEACHING TECHNIQUES—VI, Published for the Association of Women Science Teachers. Paper. 64 pp. 14×21.5 cm. 1958. John Murray, Albemarle Street, London, W.1., England. Price 3S.

CONSERVING AMERICAN RESOURCES, by Ruben L. Parson, *Professor of Geography, East Tennessee State College.* Cloth. 550 pp. 15×23 cm. 1957. Prentice-Hall, Inc., Englewood Cliffs, N. J. Price $8.65.

SOIL CONSERVATION, by J. H. Stallings, *Research Specialist, U. S. Department of Agriculture.* Cloth. vii+575. 15×23 cm. 1957, Prentice-Hall, Inc., Englewood Cliffs, N. J. Price $9.00.

CALCULUS, Second Ed., by Edwards S. Smith, Meyer Salkover, and Howard K. Justice, all *Professors of Mathematics, University of Cincinnati.* Cloth. Pp. viii+520. 14.5×23 cm. 1958. John Wiley and Sons., Inc., 440 4th Avenue, New York 16, N. Y. Price $6.50.

MATHEMATICS IN DAILY USE, 3rd Ed., by Walter W. Hart, Veryl Schult and Lee Irvin. Cloth. Pp. ix+374+43. 16×23 cm. 1958. D. C. Heath and Co., Boston 16, Mass., Price $3.20.

BOOK REVIEWS

BASIC PHYSICS (2 volumes), by Alexander Efron, E.E., Ph.D., *Chairman, Physics Department Stuyvesant High School, New York.* Cloth. Pages xii+692. 16×23 cm. 1957. John F. Rider Publisher, Inc., 116 W. 14th Street, New York 11, N. Y. Price $7.60.

This textbook is written for use in a one year high school physics course. The approach is unusual and, according to the author, is based on ten years of successful classroom experience in physics at Stuyvesant High School. The unusual approach results from what the author terms a "spiral" design in which basic principles are presented first, followed by more difficult topics. An attempt is also made to integrate modern physics and classical physics throughout the textbook.

The book is written in two volumes under one cover. The first volume is a qualitative treatment of the entire field of physics and the second is a more rigorous analytical treatment.

Book I consists of 21 chapters and is essentially a traditional treatment of mechanics, sound, heat, magnetism, electricity, light and atomic physics with emphasis on concepts generally considered to be easy for the student. Difficult topics are presented in Book II after the student has an opportunity to survey the entire field of physics.

Book II is made up of 21 chapters and treats the wave nature of sound and light, optical instruments, statics, kinematics, dynamics, energy, fluid mechanics, heat engines, electrical measurements, electrical circuit theory, radio and electronics, and nuclear energy.

Throughout the book emphasis is placed on practical applications of basic principles with appropriate illustrations. Numerous schematic drawings and graphs are presented where they are essential for an understanding of concepts. An adequate number of illustrative examples are presented to facilitate problem solving. Problems and questions of graduated difficulty are listed at the end of every chapter.

The technical vocabulary is italicized as the terms arise in the text; however, no glossary is provided. Possibly this would make the book difficult to read for the average student. Probably few would find the mathematical treatment of Book I difficult. However, students with inadequate preparation in high-school algebra, geometry, elementary trigonometric functions and logarithms may encounter some difficulty in completing all of the mathematical material in Book II. Enough material is presented so that omissions could be made without serious consequences, to handle a wide range of abilities.

Utilization of more color undoubtedly would have made this textbook more attractive to the high-school student. Its use is limited to four pages in the section dealing with the spectrum.

This appears to be an excellent textbook for use in college-preparatory physics. It would be useful for reference as well as classroom use.

J. Bryce Lockwood
Highland Park Junior College
Highland Park, Michigan

Insights into Modern Mathematics. Cloth. 440 pp. 15×21 cm. 1957. Twenty-third Yearbook of the National Council of Teachers of Mathematics, 1201 Sixteenth Street, N. W., Washington 6, D. C. Price $5.75 ($4.75 to members of NCTM).

This book is written for high school teachers. It has as its primary goal the presentation of sufficient information about the major areas of mathematics to enable high school teachers to understand the common dependence of all areas of mathematics upon the fundamental concepts underlying high school mathematics. Many readers will find some of the chapters easy reading; nearly all readers will find that some chapters will require study.

The yearbook consists of an introduction by Carroll V. Newsom (President of New York University), eleven chapters on mathematical topics, and a concluding chapter on their implication for the school mathematics curricula.

In the introduction Newsom discusses the nature of mathematics and the rapidity with which mathematics is changing. Each science seeks some pattern to which its data appear to conform. The development of patterns and the process of generalization together with deductive reasoning provide the basis for mathematics.

Chapter 2, "The Concept of Number" by Ivan Niven (University of Oregon), includes an "outline of the central number system of mathematics, from the natural numbers to the complex numbers," a discussion of the desirability of a more rigorous development, and some illustrations as to how this might be done.

In Chapter 3, "Operating with Sets," E. J. McShane (University of Virginia) has compiled the most lucid explanation of sets that I have ever read. His applications range from atoms to members of women's clubs and leagues of baseball teams. The use of ideas of set theory to clarify the subjects of relations, functions, and even counting makes this chapter very important reading for all teachers of arithmetic concepts.

Chapter 4, "Deductive Methods in Mathematics" by Carl B. Allendoerfer (University of Washington), is concerned with "the essential nature of the methods of Euclid, their influence on mathematics, their place in mathematical

thought, and their importance in the education of high school students." This very readable chapter provides an unusual opportunity for discovering the real value of mathematics.

In Chapter 5, "Algebra," Saunders MacLane (University of Chicago) shows how modern algebra deals with the familiar operations of addition and multiplication. A list of the section headings of this chapter would startle most high school teachers. A closer look would prove that even though some of these later chapters will require careful reading, and often rereading, they provide an excellent and readable reference on these topics of modern mathematics.

Chapter 6, "Geometric Vector Analysis and the Concept of Vector Space" by Walter Prenowitz (Brooklyn College), is primarily concerned with the development of an algebra of vectors. Throughout the chapter there are applications of vector methods to familiar theorems and types of problems of high school mathematics.

Chapter 7, "Limits" by John F. Randolph (University of Rochester), and Chapter 8, "Functions" by Rudolph E. Langer (University of Wisconsin), provide an introduction to analysis. Chapter 9, "Origins and Development of Concepts and Geometry" by S. H. Gould (Williams College), is readable and well-described by its title.

In Chapter 10, "Point Set Topology," R. H. Bing (University of Wisconsin) introduces some of the substance and beauty of topology. Twenty-eight exercises are included; answers are given at the end of the chapter. A study of this chapter will bring considerable insight into this relatively new branch of mathematics.

Chapter 11, "The Theory of Probability" by Herbert Robbins (Columbia University), will require study. The material is well worth the study but it should *not* be confused with the topics from probability and statistics currently being recommended for secondary schools.

The final mathematical chapter, "Computing Machines and Automatic Decisions" by Charles B. Tompkins (University of California), shows that the most complicated of decisions can be reduced to a series of essentially trivial ones if explicit rules of decision are stated. The significance of the procedure is discussed, its implications for the schools, the binary number system, the electronic elements for computers, and some early effects to be expected from the development of computers. Readers will enjoy the author's sense of humor; they may even share his view that the curricula of our high schools might well include some of the topics from this chapter.

In the concluding chapter, "Implications for the Mathematics Curriculum," your reviewer emphasizes that the primary implications of modern mathematics involve our point of view and the manner in which we present the topics considered in our classroom. The sections of this chapter are concerned with sets; numbers and operations; variables; functions; coordinates; mathematical systems; proof; statistical thinking and machine computation; terminology; generalization, abstraction, and arithmetization; goals and content (of high school mathematics); and a conclusion concerned with the services that this yearbook can render teachers of secondary school mathematics.

Many teachers have already indicated that they have found the first few and the last chapters of the yearbook very readable, the entire yearbook an aid to their understanding of the point of view of modern mathematics. As such the yearbook is very highly recommended.

Bruce E. Meserve
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Microwave Measurements by Edward L. Ginzton, *Professor of Applied Physics and Electrical Engineering, Director of Microwave Laboratory, W. W. Hansen Laboratory of Physics, Stanford University.* Cloth. Pp. xvii+515, 15×23 cm., 1957. McGraw-Hill Book Company, Inc. 330 West 42nd Street, New York 36, N. Y. Price $12.00.

The generation, detection, and measurement of microwave power in laboratory magnitudes form the central thesis of this book. In later chapters methods of

utilizing this high frequency power for the measurement of such circuit quantities as impedance, wavelength, frequency, storage factor Q, and attenuation are considered in detail. This is distinctly a treatise on electrical measurements in the microwave domain. Attention is therefore restricted largely to laboratory methods and systems with industrial and high power applications of microwaves, such as those involved in communication and radar systems, omitted. The microwave region is regarded as "that portion of the electromagnetic spectrum at which it is possible to make laboratory equipment approximately equal in size to the operating wavelength." This would therefore include wavelengths from perhaps 100 cm down to 2 or 3 mm.

The types of generators considered include triodes of special design, klystrons, reflex klystrons, traveling-wave tubes, and backward-wave tubes, with their modifications. Magnetrons are omitted largely because they are usually designed for high power. Power supply requirements for frequency and amplitude stability of microwave oscillators are discussed. While klystrons and other tubes are treated as detectors, chief emphasis is placed on semiconductor crystals for this purpose. Bolometer, calorimetric, and other methods of measuring a power flowing through a system are considered. Maxwell's equations are employed to explain field configurations in waveguides and cavities. The concept of impedance is extended to circuits with distributed parameters. Reflection from discontinuities in a system and standing wave ratios are considered.

Actually wavelengths rather than frequencies are usually measured when working in the microwave region. Frequencies, however, may be measured with high precision by the extension of methods commonly used in the lower-frequency radio region.

The author of this book is concerned chiefly with techniques of measurement. To this end, he has considered and given some detail for a number of possible methods of measuring each quantity taken up. He has evaluated each method considered, mentioned precautions to be taken in its application, and pointed out possible sources and magnitudes of errors to be expected.

Considerable familiarity with microwave principles and techniques on the part of the reader is assumed in many cases. Familiarity with lower frequency circuitry and phenomena is taken for granted. The book is intended as a basic text and reference for a first year's graduate course. Numerous footnote references to original papers and sources add to its usefulness as a reference. Unless the reader has the required background in microwave concepts and methods, this is a book for study, and not intended for casual reading.

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Trigonometry for Secondary Schools, by Charles H. Butler, *Head of the Mathematics Department, Western Michigan University, Kalamazoo, Michigan*, and F. Lynwood Wren, Julia A. Sears, *Professors of Mathematics, George Peabody College for Teachers, Nashville, Tennessee.* Second Edition. Cloth. Pages vii+360. 14.5×22.5 cm. 1957. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $2.96.

This text might well be classified "traditional." It starts with the acute angle; the solution of triangles occupies roughly forty to forty-five per cent of the space devoted to plane trigonometry. One wonders, with the increased use of calculating machines in science and industry, why there are no trigonometry texts which completely omit the logarithmic solution of triangles.

The explanations seem exceptionally good. Statements are, in general, correctly and rigorously phrased. For example, in discussing identities, the author clearly points out that we are concerned only with "permissible values of x." In reviewing the laws of exponents the definitions clearly exclude cases where the base is zero [except in the definition of the zero power—one wonders whether the omission was intentional or accidental].

Some minor points might be noted: although the text gives a careful discussion and warning about the use of the statement "the quotient is infinite" the symbol

for infinity appears in a table of values of functions of quadrantal angles. Some teachers would prefer a blank at such places. On page 42 it might be preferable to speak of rounding a number, rather than rounding an integer. On page 69 it is stated that the best way to write a power of ten, such as $10^{-3.500}$, is $10^{6.5000-10}$. What is best in one situation is not best in another. There is no mention of the principal values of the inverse functions. The treatment of trigonometric equations is limited to one page of text and forty problems.

At places the page seems somewhat crowded. In a few cases it would have been helpful to avoid placing diagram and related text on opposite sides of the page (example, pp. 177–78).

There is a very fine appendix which describes the construction and use of some simple mathematical instruments, such as the angle mirror, plane table, alidade. Problems seem ample in number and appear to be well selected.

If you are seeking a traditional text, this is excellent; if you wish to give great stress to analytic trigonometry, it is doubtful if you will be satisfied with the book.

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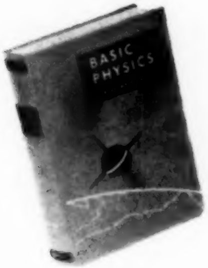

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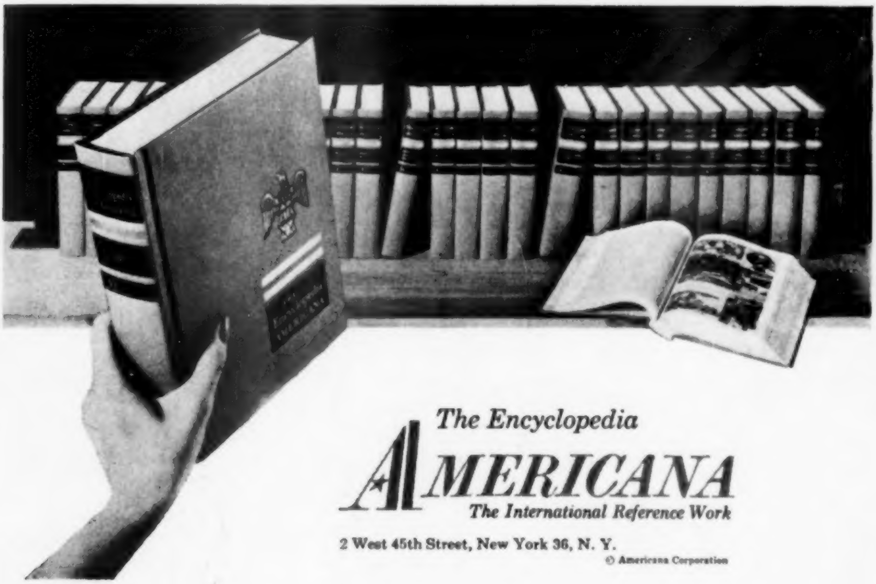

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